THE IMPACT OF INTERNET

ON URBANIZATION IN CHINA:

Empirical Evidence from Chinese City-Level Data

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Content

Abstract

China is experiencing urbanization at an unprecedented rate over the last two decades. This study explores the effect of internet infrastructure on urbanization in China, based on a panel data of 39 main cities from 2001 to 2007. Two-stage least square model was employed to ascertain the impact of internet penetration rate on urban GDP per capita in the first stage. In the second stage, urban GDP per capita, as well as other urban indicators are used to explain the degree of urbanization, which is defined in this study as urban population proportion in the second stage. Consistent with a number of the key hypotheses, the findings suggest that internet penetration rate has a direct and significant and positive influence on urban GDP per capita, and an indirect effect on increasing urban population proportion through urban GDP per capita. Economic growth continues to fuel China's urbanization.

Key words: urbanization, internet infrastructure, urban population proportion, economic growth

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1. Introduction

Urbanization refers to a process in which an increasing proportion of an entire population lives in cities and the suburbs of cities. It is also characterized by a decrease in rural-agricultural activities in favor of urban industrial activities. This rapid urban transformation has been under way in mainland China since the early 1980s. China is probably one of the fastest urbanizing countries in the world. The urban population proportion has increased from 23.01% (1984) to 44.94% (2007), excluding Hong Kong, Macau, Taiwan. The scale and pace of China's urbanization promises to continue at an unprecedented rate.[1]

Urban economists attempted to understand the process of urbanization. This is because the causal link between economic development and urbanization is unclear (Jacobs 1970); although it is widely recognized that urbanization is closely related to economic development (Bairoch 1988). It is most probable that the forces that influence urbanization interact simultaneously and reinforce each other. For example, development of urban areas significantly reinforces urbanization (Mohan 1984; Moomaw and Shatter 1995; Deng et al. 2008).

High-speed internet is seen to aid the industrialization process given its rapid development since the late 1990s. In March 1999, a low-cost, set-top box was specially designed by Microsoft Venus[2], and introduced in China, enabling cable TV to the internet connection. Since then internet penetration rate has increased at a rapid rate (Zhu and He 2002).

[1] Preparing for China's Urban Billion, McKinsey Global Institute (MGI), March 2008
[2] An project by Microsoft Corporation into the personal computing market in China

It is widely recognized that information technology (IT) is critical to economic growth, and there is much literature that point to the importance of computer-based technology and internet in economic growth (Bresnahan and Greenstein 1999; Roller and Waverman 2001; Jorgensen, Ho and Stiroh 2007). This is in line with endogenous growth theories (Lucas 1988; Romer 1990), where, the development of internet technology and relevant innovation helps effectively distribute information, foster competition, improve industry structure and then further accelerate macroeconomic growth. Urbanization encourages human capital accumulation and technology development, and cities become the engines of economic growth (Bertinelli and Black 2004).

However, there has been little empirical research on the impact of internet penetration on urbanization in China. The objective of this study is to analyze the impact of internet development on urbanization in China in two stages. Stage one tests the effect of internet penetration rate on urban GDP per capita based on annual panel data of 39 cities, and stage two applies predicted urban GDP per capita together with other factors as explanatory variables to explain urbanization. The study suggests that, internet penetration rate has had a significant positive impact on GDP per capita. Specifically, a 10% increase in the internet penetration rate has a positive impact on the annual GDP per capita by 9.74% to 11.15% points (with city and year fixed effect), which indirectly increase urbanization rate by 2.13%.

There are two main contributions of this study. First, the use of internet penetration rate as a useful parameter to explain economic growth in China.

Second. the use of an instrumental variable which incorporates internet penetration rate in influencing urbanization.

The remainder of the study is organized as follows. Section 2 briefly summarizes relevant studies on urbanization and urban economic growth from previous literature. In Section 3, we develop an Instrumental Variable (IV) approach, prepare the basic framework and discuss the data resource. Section 4 reports and discusses the results and relationship between internet penetration and urbanization in China. Section 5 concludes.

2. Literature Review

Much has been studied on the relationship between urbanization and urban economic growth but few on the impact of internet penetration. In this study, urban economic growth is defined as urban per capita gross domestic product (GDP).

2.1 Urban economic growth and the role of technology (Internet)

Solow's economic growth model has formed the basis for many urban economic growth studies (O'Sullivan 2003). This basic neoclassical model has been the basis for the study of economic growth at city level. (see Ghali, Akiyama, and Fujiwara 1978). Crihfield and Panggabean (1995) used disaggregated data and found that the neoclassical growth model performs well in explaining inter-metropolitan factor flows and convergence in per capita incomes.

Hoover (1937) and Chinitz (1961) looked at the impact of externalities on the urban environments. Information externalities were the driving force for technological innovation and hence economic growth (Romer 1990). Urban proximity can reduce the costs of shipping goods and speed the flow of ideas (Glaeser and Ponzetto, 2007), and empirical work of Glaeser (1996) suggests that telecommunications may be a complement to face-to-face interactions in urban areas. All these scale externalities are generated from specialization in production patterns (Henderson 1974) and knowledge spillover generated from information exchange. Fujita and Ogawa (1982), Kim (1988), and Black and Henderson (1999) applied exogenous growth theory at metropolitan level. Eaton and Eckstein (1997) studied the impact of technology spillovers both

within and across cities drawing from data on 39 French urban areas from 1876 to 1990 and 40 Japanese urban areas from 1925 to 1985. It was found that a significant increase in urban population was associated with the process of development. Based on Eaton and Eckstein (1997), Black and Henderson (1999) developed a fully specified endogenous urban growth model, focusing on issues of city formation and the effect of endogenous growth on changes in city sizes, numbers, and human capital levels over time, to find that localized information spillovers fostered endogenous growth.

Industry and internet are intertwined as it enables firms to expand markets and grow the economy, thus reinforcing urban growth. Internet plays a significant important role in the information technology (IT) development in the urban context. Personal computers (PCs) and laptops have become a necessity. Bresnahan and Greenstein (1999) found that the rapid growth of computer industry sustained technical innovation and commercialization. Roller and Waverman (2001) even found that about one third of growth in OECD countries over the period 1971-1990 can be attributed directly or indirectly to telecommunications. Internet infrastructure enables the exchange of data across multiple locations and helps decentralized information processing (Hayek 1945); improves the processing of information, resulting in significant growth on firm level (Stiroh 2002); greatly accelerates individual labor productivity growth (Jorgenson, Ho, and Stiroh 2007); and it also has an important knowledge spillover effect and create positive externalities, for instance, helping the presence of complementary inputs such as skilled labor (Autor, Levy, and Murnane 2003).

2.2 Urbanization and Urban economic growth

Based on previous research, the universal acknowledged index for a urbanized area, is the proportion of the entire population living in urban areas (Davis and Golden 1954; Moomaw and Shatter 1996; Davis and Henderson 2003; Bertinelli and Black 2004; Deng et al. 2008). One other commonly used index is urban population density (people per square kilometer), which has been frequently used in understanding the and how cities function. Research related to explaining urban density stride across disciplines, including economics, health, innovation, psychology and geography. However, given the dynamic changes in China, city size is constantly adjusted, which makes urban population density not useful for studying urbanization in China.

The overall growth and expansion of cities has been of long-standing interest to economists, because strong urban economies are the backbone and motor of the wealth of nations (Jacobs 1984). The long-term trends of urbanization and its relationship with economic development remain debatable. However, there are studies that strongly suggest that urbanization is positively correlated with economic development.

Mills (1967) suggested that urbanization was a response to per capita income and employment opportunities provided in cities. Mohan (1984) found Engel demand effects acted as a catalyst in the urbanization process as development occur in an economy. In other words, per capita income increase had a positive effect on urbanization. Moomaw and Shatter (1996) also showed that a nation's urban population percentage increased with GDP per capita; industrialization; export orientation; and possibly, foreign assistance. Davis

and Henderson (2003) demonstrated urbanization increases as GDP per capita rises. It also found that per capita income significantly accelerated China's urban expansion, based on a three-period panel data set of high-resolution satellite imagery data and socioeconomic data as empirical-based evidence (Deng et al. 2008).

Some studies however demonstrate the lack of relationship between urbanization and economic growth (McCoskey and Kao 1998; Bertinelli and Strobl 2003).

2.3 Other factors influencing urbanization

2.3.1 Economic factors

Agriculture's share in the economy decreases with urbanization (Moomaw and Shatter 1996). Numerous studies demonstrate that the urbanization is driven by upgrading of economic structure and the shift from agriculture to industry and services. As manufacturing and service sector activities develop and prosper in cities, agriculture's share of GDP declines, thereafter firms and workers cluster in cities to take advantage of localized external economies of scale (Davis and Henderson 2003). Deng et al. (2008) provided empirical support using Chinese data from the late 1980s to 2000. It was found that share of secondary industry and tertiary industry in GDP positively influenced urban core expansion and urbanization in China.

Mills (1967) suggested urbanization might be due to the openness of an economy. First, it may increase the importance of transportation nodes, which are present mostly in urban areas. Second, it may increase demand for

marketing, financing, and communication (face-to-face contact) making an urban location more important.

Syrquin and Chenery (1898), in classifying the structure of economies, concluded that the degree of openness of an economy is important and suggested indicators such as the share of primary or manufactured goods exported as a share of exports in GDP as proxy measure.

Urbanization leads to concentration of people in urban areas. This may lead to inequality in income between urban and rural residences (Kuznets 1955; Oshima 1962; Becker 1985). However, the income gap might be a pull factor for people in China to move to cities.

Unlike the early stage of urbanization in European countries, rural migrant workers in China do not register as urban resident households in short term. However, they contribute to construction, consumption, economic growth and urbanization. In 2009, the number of floating population in China was estimated at 180 million. About 149 million are estimated to be rural migrant workers.[3] More than 80% floating population in urban areas consist of peasants from other cities. In the first six months of 2009, there were over 6 million floating workers in first half year of 2009 in Guangzhou. This is about 80% of resident population.[4] These numbers suggest that the income gap between urban and rural residents is still a pull factor in the urbanization process.

[3] Jiantang MA, Director of National Bureau of Statistics, Press conference, Beijing. January 21, 2010.

[4] Review meeting of Comprehensive Security Management, Guangzhou Comprehensive Security Management Committee. July 24, 2009.

2.3.2 Non-economic factors

Lower cost of transportation and communication leads to urbanization as they facilitate exchange of goods and services and the movement of goods and people. The size, structure, and efficiency of an urban area are influenced by the transportation system (Mills 1972). D ́emurger (2001), using panel data from a sample of 24 Chinese provinces between 1985 to 1998 period, showed that transport facilities did account significantly for observed differences in growth performance across provinces. Transportation infrastructure reduces the burden of isolation and speeds up urbanization. Furthermore, improvement in transportation infrastructure makes traveling faster and more convenient, and at the same time, reduces the cost of commuting and transportation (Deng et al. 2008). Transportation costs determine urban spatial size directly (Muth 1969; Wheaton 1974; Deng et al. 2008), as lower transportation costs increase the urban comparative advantage for both production and consumption (Graves and Sexton 1979; Mills 1972) and accelerate urbanization.

Energy resource and environment quality are critical determinants of social sustainability. There has been an increase in research of urban energy consumption (Huang 1993; Shiu and Lam 2003; Yoo 2005) and environment protection (Wackernagel and Rees 1996; Bertaud 2003). Historical energy consumption of Australia, for example, has had significant impact on the development and operation of cities (Troy et al. 2003). Ferguson, Wilkinson and Hill (2000) found a strong correlation between city development and electricity consumption based on data of 100 countries.

2.4 Summary

Figures 1, 2 and 3 illustrate urbanization trends, urbanization rates, GDP per capita, (in RMB) and internet penetration rate for 39 Chinese cities (refer to Table 1 for city code). Apart for some cities, most exhibit increasing trends.

For example, in 2003, Haikou city (city code 33) merged several neighboring districts, and increased the urban area to ten times its original size. The adjustment added a large rural population and seen to indicate a decline in urbanization rate, as showed in Figure 1c.

A similar reclassification of the urban area in Zhuhai (city code 30) and Foshan (city code 31) was carried out in recent years. It involved removal of four counties and integration of the city-level administration. This led to huge investment in city infrastructure such as subway construction, which attracted large amount of foreign direct investment from multinational enterprises. All permanent residents in Zhuhai and Foshan became non-agriculture in the period 2003 and 2004 respectively due to fast pace of urbanization (see Figure 2c). In the absence of any mergers and expansion, Dongguan's (city code 32) rapid increasing GDP per capita did not result in growth in urbanization.

In general, we find a positive correlation between these indicators in most cities. However, the pace of urbanization differ across different parts of China (East, Middle and West) urbanization are positively related to GDP per capita and the spread of internet penetration.

This study attempts to look at urbanization in Chinese cities, by incorporating internet penetration rate in urban economic growth.

3. Theoretical Framework and Data

3.1 Model set-up

Urban Residents in China consist of two groups of people: 1. Permanent household register of residents, e.g. those considered as "Hukou" [5] holders in China; 2. Migration residents without "Hukou".

Economic growth attracts millions of migration workers into cities. This group plays an important role in Chinese Urbanization Progress, in terms of infrastructure construction, commodity production and supply, stimulating domestic demand, and even international trade. They form an indispensable constitution of population of urban residents.

Thus, we employ the number of average household registers plus two thirds [6] of the Migration residents as Urban Residents for the city. We adopt Urban Population Portion (urban residents over total population of the city) as the index of urbanization rate. Since the movement of migration residents is greatly dominated by the economic level of city, we consider urban population portion as endogenous, which is driven by economic development.

Substantial research studied on the reverse causality between Urbanization and Urban economic development. We adopt Internet Penetration rate as an Instrumental Variable (IV) to help study the impact of internet development on urbanization for two reasons:

[5] Hukou: A certificate of Registered Household. It's a unique product under Chinese household register system.

[6] The proportion is estimated 2/3 because the overwhelming majority of temporary residents in cities are rural migrant workers, who live in cities on an average of eight months annually.

1. Internet Penetration rate is exogenous in the period (2001-2007) of this study. It has only eight-year history in China since 1999. Due to lack of infrastructure foundation and unsophisticated technology, development of Internet was mostly driven by government policy.

2. Internet Penetration rate, as one form of Information technology, is the driving force for information externality, technological innovation and hence economic growth (Romer 1990, Henderson 1974, Eckstein 1997). Substantial study revealed a great direct effect from information technology (the Internet) on economic growth. However, the motive for transformation from rural to urban residents is not purely because of internet infrastructure. Thus, we can safely affirm an indirect impact of Internet on Urbanization through urban economic growth.

First, urban economic growth aids in economic structure upgrade. We observe a shift between different industries as GDP per capita increases. When the second and tertiary industries develop, peasants view this as an opportunity "to be liberated" from farming. Second, a booming economy leads to increased division of labor and larger markets generating economies and efficiency for mass communication and transportation. This in turn leads to the further development of urban areas. In addition, growth of the city needs strong economic and "hard" infrastructure support. Although China is one of the fastest urbanizing countries, the urbanization level is still below the global average (see Table 2). Without adequate economic investment in infrastructure such as transportation systems, utilities and power station, or other basic facilities, urbanization will not be sustainable.

A two-stage least square approach is employed in this study. Stage one applies a growth model which looks at the relationship between internet penetration rate and the urban economy. Stage two uses GDP per capita together with other explanatory variables to explain the impact on urbanization.

3.1.1 Urban economic growth and Internet penetration

The size of an urban economy is measured in several ways, such as the total value of output (goods and services) produced in urban area (O'Sullivan 2003). A typical model for the urban economy can be illustrated as follows.

$$Y = f(K, L, H) \tag{1}$$

Mankiw, Romer, and Weil (1992) model augmented Solow's model to include accumulation of human capital and physical capital.

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} [A(t)N(t)]^{1-\alpha-\beta} \tag{2}$$

Given constant returns to scale and the three inputs physical capital (K), population (N), human capital (H), and the state of technology (A), the steady state is given by:

$$\log y_{it} = \log A_{it} + \beta_2 \log s_{it} + \beta_3 \log h_{it} + \beta_4 n_{it} \tag{3}$$

where, y_{it} is GDP per capita, s_{it} is the propensity to accumulate physical capital, h_{it} is average human capital accumulation, n_{it} is the growth rate of population, and finally, A_{it} is the state of the technology, in city i at time t. The empirical observations of continuous growth in per-capita GDP can be expressed by a technological state that increases over time and drives

economic growth. Assuming the technological state evolves an exponential growth path, the state of technology can be written as:

$$A_{it} = A_{i0}e^{\lambda_{it}} \tag{4}$$

where, λ is the growth parameter of technology development. A permanent shift in GDP per capita is assumed once internet has been introduced. Internet penetration in the entire economy may also positively affect urban economic growth by continuously spurring innovation processes. To model the effect of internet penetration on economic growth, λ can be rewritten as:

$$\lambda_{it} = \beta_i + \beta_1 P_{it} \tag{5}$$

where, β_i is the specific technology growth parameter for city i, P_i is the internet penetration rate, i.e., the share of the population that has subscribed internet service in city i. In the first several years of Internet development in China, government policy and budgeting plays a very important role, thus we consider Internet Penetration as exogenous.

Substitute equation (4) and (5) into (3), we obtain,

$$\log y_{it} = \log(A_{i0}e^{\beta_i+\beta_1 P_{it}}) + \beta_1 \log s_{it} + \beta_2 \log h_{it} + \beta_3 n_{it} \tag{6}$$

A_{i0} and β_i are fixed for city i, and can be merged into the fixed effect of each city. This yields an econometric, a specification of equation (3),

$$\log y_{it} = \alpha_i + \beta_1 P_{it} + \beta_2 \log s_{it} + \beta_3 \log h_{it} + \beta_4 n_{it} + \varepsilon_{it} \tag{7}$$

Thus, β_1 gives the effect of internet infrastructure on GDP per capita, α_i captures city-specific effects, and ε_{it} is an error term.

3.1.2 Urbanization and Urban economic growth

Based on Moomaw and Shatter (1996), more factors are included to explain urbanization, such as, the economic development, technology spread, communication capacity, living condition, per capita resource and environment quality, etc. These factors are useful in a comprehensive evaluation of a city's development. As showed in Table 3, nine proxies are employed to explain the corresponding city's development indices.

In this case, the relationship between the degree of urbanization and relative city indices is given in equation (8). The abbreviations are explained in Table 3.

$$d_{urbanization} = f(ED, IS, OPEN, SGF, TI, EP, ECC, TC \dots) \quad (8)$$

A series of proxies are chosen to express different aspects of urban activities in the empirical model. These include GDP per capita, y_{it}, the indicator of economic development. GDP measures the value of all goods and services produced in the city during the year. Primary and tertiary industry as a proportion of GDP, $GDP1_{it}$ and $GDP3_{it}$ respectively are also included, to further indicate the industrial structure, because urbanization speeds up as industrial structure upgrades (Davis and Henderson 2003). The variable $openness$ is measured by actual utilized FDI over GDP to show the degree of openness of cities. $iratio$ stands for income ratio of urban and rural residents, to reveal income distribution and social fairness. As a proxy for transportation cost, the inverse of road density (r) measures the railway, road length per square kilometer. Other variables includes public green space per capita (g), per capita electricity consumption (e), and cell phone penetration rate ($celp$),

as proxies for the demand in environment quality, energy consumption and telecommunication of a city respectively, and are highly related with urban residents accumulation.

Several assumptions are made. First, we regard the effect of all other possible factors for urbanization as fixed effect for each city. It rules out the possible impact of technology development, labor market status, etc. Second, all explanatory variables are exogenous, due to data limitations.

Therefore, urbanization for city i at period t as represented b the variable urban population proportion ($uPopP$) can be explained through equation (9) as

$$uPopP_{it} = \alpha_i + \alpha_t + \beta_1 \log y_{it} + \beta_2 GDP1_{it} + \beta_3 GDP3_{it} + \beta_4 openness_{it} + \beta_5 iratio_{it} + \beta_6 \log r_{it} + \beta_7 \log g_{it} + \beta_8 \log e_{it} + \beta_9 \log celp_{it} + \varepsilon_{it} \quad (9)$$

where, α_i capture city specific effects, α_t captures time fixed effects, and ε_{it} is an error term.

3.2 Data Availability

The "city" in China is defined as a local administrative and jurisdictional entity. There are three different administrative levels of cities in China's urban system: municipalities, prefecture-level cities and county-level cities. Small settlements with township or lower administrative levels are not treated as "cities". Scale of urban residents is the major criteria to distinguish cities. Economic and political importance is also one of the considerations in defining cities. The definition of cities has largely been consistent with global definition (Anderson and Ge 2005).

39 cities (most are municipalities and some are prefecture-level cities) were selected based level of economic development, city area, location advantages, environment, popularity and urban construction, etc. Most cities selected had urban residents of one million in 2001, and two million by 2007. We also consider prefecture-level cities based on high reputation, regional and political status. Urbanization of the prefecture-level city developed very quickly, especially the prefecture-level cities located within the Yangtze River Delta and Pearl River Delta (Wang and Han 2009).

China's National Bureau of Statistics (NBS) reports information on both "Diqu" (Urban area plus rural area within the same administration) and "Shiqu" (only urban area). The latter defines the metropolitan area closer to international standards (Fujita et al. 2004). We employ "Shiqu" in this study.

Internet penetration is measured by the number of internet subscribers per 100 habitants, as defined by China Statistical Yearbook telecommunication portal. Since internet was introduced to China in March 1999 (Zhu and He 2002), data is only available from 2001.

GDP is expressed based on 2000 Purchasing Power Parity (PPP). The propensity to accumulate physical capital is proxied by the ratio of fixed capital to real GDP. Human capital index is calculated and reported by China's National Bureau of Statistics (NBS) based on the China Population Census in 2000, and is regarded to remain the same until 2007 for each city.

Due to the lack of city-level trade volume data, actual utilized foreign direct investment (FDI) over GDP is adopted as a measure of the degree of openness. The income ratio of urban and rural residents is derived from taking the ratio

of per capita disposable income of urban households over net income per capita of rural households.

Amount of urban resident (contain migration residents) is used to derive per capita indices in the study.

All other data on economic performance and urbanization are obtained from China Statistical Yearbook, China Regional Economic Statistical Yearbook, Finance Yearbook of China and China Urban Statistical Yearbook. Some missing data are obtained from local government statistical yearbooks. Dataset used is annual up to 2007.

4. Results and Interpretation

4.1 The relationship between internet penetration and urbanization in China

4.1.1 Result of 2SLS

Table 5 reports the correlation matrix of all variables in this study. Some correlation coefficients are relatively high. To test the severity of multi-collinearity problem, we employ variance inflation factor (VIF) and thus is reported in Table 6. No individual VIF is greater than 10 or Tolerance is below 0.1. We can therefore exclude for multi-collinearity problems (Bowerman and O'Connell 1990; Menard 1995).

Table 7 reports estimation results of equation (7) that models the effect of internet penetration on urban GDP per capita both with and without city fixed effect. Model 1 refers to the sample of 39 cities with complete data, and, Model 2 shows results for the same 39 cities, but without controls for physical and human capital indexes and urban resident growth. A reasonable assumption made is that internet development leads to innovation in technology, thereby generating a positive change in physical and human capital accumulation. Both Models 1 and 2 include on a random effect base ($\alpha_i = 0$ in equation (7)). Models 3 and 4 allow for fixed effect for each city ($\alpha_i \neq 0$ in equation (7)).

From Table 7, we observe that the coefficient of the internet penetration rate is positive and significant in all the four models. As we can expected, the value is larger from models without controls (1.138>1.051; 1.115>0.974).

Since cities in different parts of China are of different economic levels and environment, we consider the results with city fixed effect (Model 3 and Model 4) more credible. The *F*-test of joint significance of fixed effect models is 15.12 and 14.98 respectively, which reject the null hypothesis of coefficients jointly being zero. The magnitude of the coefficients suggest that, given control for city and year fixed effect, a ten percentage point increase in the internet penetration rate is associated with an increase annual GDP per capita of 9.74 to 11.15 percent points.

Physical capital and human capital have a positive impact on GDP per capita while urban resident growth has a negative impact on GDP per capita. This finding is consistent with Romer (1990), who suggested that a large population does not necessarily generate growth. However, the effects of the increasing in the stock of physical and human capital, as well as the development of technology has a far greater impact on GDP per capita than that of population growth.

Table 8 reports the results for the second stage. By plugging Predicted value of Log of GDP per capita in Model 1 of stage 1 into stage 2, we try to study the indirect impact of Internet penetration rate (IV) on Urbanization. Model 1 strictly follows 2SLS method and reports results on predicted GDP and all explanatory variables except IV Internet Penetration Rate.

To further study the impact of other variables on Urbanization, Model 2 includes all variables in equation (9), Model 3 reports results without control for explanatory variables other than economic index, while Model 4 only controls for predicted GDP per capita (from the first stage).

Results reported in Table 8 are as postulated. The coefficients of predicted GDP per capita are all significant and positive for all three models, which suggest urban economic growth is the driving force behind urbanization in China. For example, a ten percentage point increase in urban GDP per capita is associated with an increase of 2.19 percentage point in urban population proportion. An increase in internet penetration rate by a ten percentage point leads to an indirect increase in the urban population proportion by 2.13 percentage-point (e.g.$10*\frac{9.74}{10} * 0.219$).

The share of primary industry has been observed to decrease as proportion of GDP as urbanization increases. This is shown in Table 8. This effect is significant as peasants migrate from rural places to urban area, from agricultural sector to secondary and tertiary sectors, and is the direct result of urbanization process. We also observe that the development of tertiary industry did not have much impact on urbanization. A possible explanation is the lack of maturity and sophistication of the tertiary sector. The service sector has been increasing its contribution to China's economic output in recent years. However, the major driver is still the manufacturing sector.[7]

The effects of annual utilized FDI/GDP and income ratio between urban and rural residents are not significant. The later variable shows significance at 10% level in Model 2 which suggests that certain groups of people move to urban areas due to the income gap.

[7] Deshui LI, Commissioner of the National Bureau of Statistics (NBS), Xinhua Press, July 27, 2005

The coefficients of cell phone penetration rate and inverse of road density both suggest development in telecommunication and transportation significantly contributes to urbanization in China. A 1% increase in cell phone penetration leads to a 0.024% increase in urban population proportion; and a 1% decrease in transportation cost lead to a 0.309 increase in urban population proportion. Cities with higher cell phone penetration rate are likely to have lower communication cost. Cities with a higher road density (lower inverse of road density) are likely to have lower transportation costs. Improvements in telecommunication and transportation increase mobility of population and lead to changes in urban structure. For example, it reduces the costs of communicating, commuting and freight costs. This provides incentives for economic activity to relocate further away from the city centre. The movement expands urban cores and increases overall urbanization level of cities.

Public green space per capita is not significantly related to urbanization, as in Table 8. The explanation may be during the years of 2000 to 2007, Governmental awareness and high quality living was not a priority in a developing country like China. Most people in China did not put emphasis on high quality living circumstance, and were not environmentally-conscious. However, continuous economic growth has brought substantial wealth to Chinese residents, who nowadays care more about living environment and green space. Government has put greening as one of the top priorities. We can safely expect Greening to become a critical index for dwelling decisions and urbanization level in the future.

Consistent with many previous studies (Huang 1993; Ferguson, Wilkinson and Hill 2000; Troy et al. 2003; Shiu and Lam 2003), the results in Table 8 show a strong correlation between urban development and electricity consumption. This confirms the positive influence of energy resource in urbanization.

4.1.2 Study on Explanatory Variables for Urbanization

Strong capital formation in an economy supports the development of various infrastructures, including electricity, transportation infrastructure, production capacity, urban construction, etc. All explanatory variables in equation (9) are derived from adequate accumulation of capital. To further study the impact of these variables on Urbanization without conflict with the theoretic IV method, we verified the regression in Model 2, 3, and 4 of the second stage by linking up Log of Capital formation / GDP and the variables for urbanization, i.e. Primary and Tertiary Industry proportion of GDP, Annual utilized FDI / GDP, Income ratio of urban to rural residents, Cell phone Penetration Rate, Inverse of Road Surface Area per Capita, Log of Public Green Space per Capita, Log of per Capita Electricity Consumption for Residential Use. Table 9 reports the regression results. All coefficients are significantly related to Capital formation, which confirms the Capital formation covers all the impact from these variables, and thus supports the method of Model 2, 3, and 4 of second stage.

4.2 Impact of Internet on Urbanization in China

The results suggest that internet infrastructure does play an important role in accelerating the economy growth. This could be explained though several ways:

First, internet serves as an incubator of human capital development in an urban area. Internet infrastructure and application help in information distribution, and greatly improves efficiency for both individual and organizations. In Table 5, we observe that human capital is strongly correlated with internet penetration rate. In a knowledge economy, information is spreading with unprecedented speed over internet such as emailing. Internet aids in self-learning with remote telecommunication, to access the latest news, to share information, to keep up with schedules, and so on. Internet enables and enhances human capital integration into the urban economy.

Second, internet leads to strengthening of market forces. This is essential and complements industrial development. It contributes positively to changing business practices and raising productivity, and spawns a "tectonic upheaval" where vast networks drive business in a global, intangible, and inter-linked environment. Alan Greenspan[8] speculated that the "rapid acceleration of computer and telecommunication technologies can reasonably be expected to appreciably raise our productivity and standards of living in the twenty first century certainly, and quite possibly in some of the remaining years of this century."

Internet is indispensible for workers in both multi-national companies and small local firms, especially in companies operating changing conditions such as the financial industry. First hand and real time information is of great importance. Bloomberg is a typical example. The customer service center of Bloomberg requires financial analysts to answer calls from all over the world

[8] Chairman of Federal Reserve, U.S.A., 1996

on all financial matters. These include the latest information in markets covering stocks, foreign exchange, options, and futures. Internet enables and facilitates Bloomberg's customers seek online guidance, and connects time zones as trading closes in Asia and begins in Europe.

Increasing number of firms utilize the internet to enhance competitiveness through establishing web servers, and set up websites with user friendly interfaces giving full details of products to customers. Internet aids companies in improving corporate image, and maintain close contact with customers. The low cost of the new communication channel save users time and financial expenditure. One can expect a market to be more competitive and delivering a higher sophistication of services. Other examples such as internet-based device also promote telecommunication, video and telephone conferences.

The internet aids in the development of emerging industries and niche markets, leading to new businesses and jobs. The advent of information technology facilitates geographic separation of production (Liao 2010). An extraordinary example is the huge success of Taobao in China. Taobao offers non-stop online platform for shopping, socializing and information sharing for consumers, and is founded by the parent Alibaba Group. Taobao facilitates transactions, between individual consumers and a wide range of sellers such as retailers, wholesalers, and other individuals. Taobao developed on a broad base of internet users and facilitated opportunities to entrepreneurs. Consumers in Shenzhen are able to shop commodities produced in Beijing online at a competitive price, without travelling or queuing. In 2009, transactions for electronic commerce (E-commerce) of Chinese small and

medium-sized enterprise totaled US$55.3 billion, of which, US$29.4 billion was based on Taobao's activities. Taobao's turnover in 2010 is expected to increase to US$58.8 billion, exceeding that of eBay Inc.[9] The development of E-commerce is contributing more to the urban economy through the internet, by stimulating related industries such as express delivery, financial instruments and smallware production. In addition, cyber marketing, network design, online game, and many other fields of work are emerging with the advent of internet. This positive development on social division of labor should lead to greater social mobility.

Internet is a vital catalyst for urban economic growth in the information age, and profoundly reinforces urbanization.

There is significant evidence that an increase in the cell phone penetration and road density have a positive effect on urbanization. Internet is expected to have the similar or even larger impact. It shows that business support services are increasingly sent to small localities for cost savings and being separated from their downstream industries (Liao 2010), primarily because they can benefit from higher urban productivity without bearing urban costs.

Liao (2009) adopted data in U.S. cities to study the effect of new technologies facilitating computerization and outsourcing, which reinforce the development in rural places. The effect of internet on facilitating geographic separation may not be evident because of the relatively short period of analysis (2001-2007) of this study. However, given a longer time frame, the impact of the internet will reduce the cost of communication, create new economic activities and expand

[9] John Spelich, Vice President of Alibaba Group, January 25, 2010

markets. When firms and investment are provided with efficient communication and logistics capacity, urban core will expand into growth poles and further fuel rural-urban migration.

Internet penetration reinforces urbanization in two ways. First, it acts as a catalyst in the distribution of ideas and information, and it enhances technology evolution and human capital accumulation. This in turn stimulates economic growth and expansion of cities. Second, as economic growth lead to industrial restructuring, new and niche markets emerge, resulting in greater demand for labor.

5. Conclusion

This study is one of the few which looks at the impact of internet on urbanization in China employing a two-stage least square method. First stage employs endogenous economic growth model, where internet penetration rate is integral part of the state of technology of an economy. This is because internet which effectively distributes information, contributes to high productivity growth, information sharing pool and the development of social division to the urban economy. Improvements in economic performance eventually generate economic growth.

The second stage looks at the relationship between urban economic growth and urbanization. The hypothesis here is that degree of urbanization in China is reinforced by urban economic growth together with other factors, such as urban GDP per capita, primary and tertiary industry proportion, actual utilized foreign direct investment, income ratio of urban and rural residents, inverse of road density, public green space per capita electricity consumption per capita and cell phone penetration rate.

Urban population proportion is used the index for degree of urbanization. This is drawn from a panel data set of 39 main cities in China from the year 2001 to 2007. It was found that a 10 percent increase in internet penetration rate leads to 2.13 percentage point increase in urban population proportion through the indirect influence of urban economic growth. This supports the hypothesis. The study also provides empirical support to demonstrate that internet development contributes to urban economic growth, which in turn reinforces urbanization.

It was also found that improvements in both telecommunication and transportation have a significant impact on urbanization.

In this study, we consider Internet Penetration Rate as exogenous. It is convincing in China for the first 10 ten years (including the period of this research) development of Internet, due to the necessary and influential government policy. However, with less media sanction and growth of economy, Internet Penetration Rate may be also driven by city development or even urbanization. We will further study the impact of Internet Penetration Rate as an endogenous variable in the future.

There are two limitations of the study. First, the statistics on urban population is difficult to obtain. Further, non-agriculture residents may not stay in cities. Access to internet enables work or business to be carried out from city location. Facilitated together with improvements in telecommunication and transportation, firms and factories can relocate to suburban or even rural places in search of lower rental cost and labor cost. This allows a large number of labor force to move to remote areas. It must be noted that migrant workers (most are reported as agriculture residents) who work and live in cities like Shenzhen and Shanghai are highly mobile. We cannot ignore their contribution to the construction sector as infrastructure development contributes to urban GDP.

Second, rural-urban migration increases agglomeration diseconomies and urban un-sustainability will further complicate the analysis. This is due the increasing inequality of income between developed cities and less developed regions. One other problem is the growth of negative externalities, such as

traffic congestion and air pollution, in the urban areas where population and demand for mobility exceeds optimal conditions (Henderson 1974). Furthermore, the rapid immigration caused by inter-sectoral income inequalities generates additional problems, such as unemployment and housing shortage (Sovani 1964). These problems are generated by over-urbanization. Technological improvements alone will not solve the negative impacts of over-urbanization. Rather the problems must be addressed for a holistic approach which takes into account area such as good land use planning, human resource development, good governance, efficient investment strategy and development strategy.

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Appendix:

Table 1: City and Code

City	Code	City	Code	City	Code
East China		Ningbo	18	Changchun	11
Beijing	1	Wenzhou	19	Harbin	12
Tianjin	5	Shaoxing	20	Hefei	21
Shijiazhuang	6	Fuzhou	22	Nanchang	24
Shenyang	9	Xiamen	23	Zhengzhou	27
Dalian	10	Guangzhou	4	Wuhan	28
Jinan	25	Shenzhen	3	Changsha	29
Qingdao	26	Zhuhai	30	**West China**	
Shanghai	2	Foshan	31	Chongqing	35
Nanjing	13	Dongguan	32	Chengdu	36
Wuxi	14	Haikou	33	Guiyang	37
Suzhou	15	Sanya	34	Kunming	38
Yangzhou	16	**Middle China**		Xi'an	39
Hangzhou	17	Taiyuan	7	Huhehaote	8

Table 2: Urban population Proportion in 2007 (%)

Global average	49.9
High-income countries	77.7
Middle-income countries	48.1
Low-income countries	28.7
U.S.A.	81.7
E.U.	73.2
Japan	86.3
Korea	81.5
Russia	72.8
China	44.9

Sources: World Bank, World Development Indicators (2007)

Table 3: Explanatory Variables for Degree of urbanization

Index		**Proxy**	
Economic Development	ED	GDP per capita	y
Industrial Structure	IS	Primary/Tertiary industry proportion of GDP	$GDP1, GDP3$
Openness of Economy	$OPEN$	Actual Utilized FDI/GDP	$openness$
Social Fairness	SF	Income Ratio of Urban and Rural residents	$iratio$
Transportation Infrastructure	TI	Inverse of Road density	r
Environment Protection	EP	Public Green Space Per Capita	g
Energy Consumption Capacity	ECC	Per Capita Electricity Consumption	e
Telecommunication Capacity	TC	Cell phone penetration rate	$celp$

Table 4a: Descriptive Statistics

City	GDP per capita (log)		Capital formation/GDP		Human capital 2000	Growth of Urban population		Internet Penetration rate		Urbanization Rate		Cell phone Penetration Rate	
	Mean	S.D.	Mean	S.D.	Mean	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
East China													
Beijing	4.57	0.23	0.46	0.11	92.22	0.01	0.04	0.44	0.20	0.71	0.05	1.11	0.27
Tianjin	4.49	0.18	0.42	0.05	75.53	0.04	0.05	0.31	0.12	0.59	0.01	0.58	0.22
Shijiazhuang	4.46	0.09	0.46	0.12	64.27	0.05	0.05	0.36	0.08	0.33	0.07	0.73	0.52
Shenyang	4.47	0.17	0.44	0.22	69.49	0.01	0.00	0.24	0.08	0.64	0.01	0.57	0.17
Dalian	4.65	0.16	0.36	0.18	67.20	0.01	0.01	0.31	0.10	0.54	0.03	0.73	0.26
Jinan	4.52	0.13	0.34	0.06	67.42	0.04	0.07	0.21	0.08	0.51	0.09	0.60	0.28
Qingdao	4.60	0.18	0.35	0.06	67.87	0.02	0.01	0.26	0.06	0.49	0.09	0.87	0.32
Shanghai	4.71	0.16	0.40	0.03	78.73	0.02	0.04	0.48	0.27	0.80	0.05	0.97	0.30
Nanjing	4.52	0.14	0.48	0.15	71.04	0.09	0.12	0.17	0.06	0.66	0.09	0.67	0.26
Wuxi	4.72	0.16	0.37	0.17	64.87	0.13	0.31	0.25	0.08	0.56	0.14	0.87	0.32
Suzhou	4.68	0.22	0.37	0.15	68.32	0.13	0.31	0.24	0.07	0.47	0.05	0.92	0.46
Yangzhou	4.48	0.13	0.38	0.09	64.93	0.14	0.36	0.18	0.07	0.34	0.06	0.52	0.20
Hangzhou	4.66	0.14	0.41	0.07	70.25	0.16	0.39	0.20	0.11	0.42	0.05	0.98	0.40
Ningbo	4.70	0.16	0.48	0.12	65.51	0.09	0.21	0.39	0.17	0.30	0.03	1.20	0.52
Wenzhou	4.59	0.14	0.40	0.08	59.18	0.03	0.03	0.29	0.15	0.19	0.01	1.20	0.62
Shaoxing	4.49	0.15	0.58	0.18	59.17	0.11	0.27	0.23	0.09	0.24	0.05	0.83	0.40
Fuzhou	4.58	0.08	0.44	0.12	60.65	0.03	0.01	0.33	0.05	0.34	0.05	0.63	0.22
Xiamen	4.72	0.14	0.39	0.14	74.53	0.02	0.05	0.31	0.09	0.60	0.08	1.02	0.39
Guangzhou	4.76	0.17	0.35	0.08	77.63	0.06	0.13	0.46	0.12	0.69	0.08	1.76	0.72
Shenzhen	5.29	0.15	0.30	0.07	89.66	0.08	0.02	0.85	0.07	0.89	0.10	6.21	2.01

Zhuhai	4.81	0.09	0.34	0.04	71.76	0.13	0.25	0.32	0.05	0.87	0.16	1.56	0.86
Foshan	4.68	0.19	0.29	0.04	71.03	0.75	2.07	0.25	0.02	0.76	0.29	1.60	0.54
Dongguan	4.82	0.31	0.28	0.05	83.60	0.02	0.00	0.30	0.08	0.35	0.07	5.04	2.37
Haikou	4.33	0.07	0.48	0.04	80.75	0.18	0.41	0.21	0.02	0.69	0.15	0.66	0.17
Sanya	3.99	0.23	0.62	0.15	57.58	0.02	0.01	0.10	0.05	0.43	0.07	0.28	0.08
Middle China													
Taiyuan	4.29	0.20	0.41	0.07	64.71	0.03	0.01	0.14	0.04	0.68	0.02	0.58	0.27
Changchun	4.47	0.13	0.38	0.16	66.22	0.03	0.02	0.14	0.13	0.43	0.01	0.98	0.35
Harbin	4.39	0.12	0.40	0.05	64.37	0.06	0.10	0.25	0.16	0.47	0.01	0.50	0.10
Heifei	4.43	0.18	0.60	0.23	66.21	0.05	0.03	0.22	0.07	0.37	0.04	0.74	0.20
Nanchang	4.41	0.14	0.41	0.21	62.46	0.04	0.02	0.26	0.08	0.44	0.03	0.80	0.29
Zhengzhou	4.35	0.16	0.46	0.13	65.18	0.03	0.01	0.18	0.06	0.38	0.03	0.75	0.41
Wuhan	4.38	0.19	0.43	0.07	73.50	-0.03	0.14	0.15	0.07	0.61	0.02	0.63	0.34
Changsha	4.52	0.15	0.51	0.15	65.45	0.03	0.01	0.31	0.09	0.34	0.02	0.71	0.27
West China													
Chongqing	4.09	0.13	0.57	0.20	68.06	0.09	0.16	0.08	0.05	0.24	0.02	0.50	0.18
Chengdu	4.43	0.12	0.57	0.11	69.89	0.06	0.09	0.17	0.08	0.41	0.08	0.70	0.22
Guiyang	4.21	0.13	0.59	0.10	60.99	0.02	0.01	0.14	0.06	0.45	0.08	0.58	0.16
Kunming	4.47	0.11	0.34	0.06	67.35	0.02	0.01	0.10	0.06	0.39	0.06	0.84	0.11
Xi'an	4.26	0.10	0.52	0.20	67.77	0.05	0.08	0.19	0.05	0.44	0.02	0.49	0.22
Huhehaote	4.42	0.30	0.48	0.07	61.95	0.01	0.01	0.11	0.06	0.45	0.01	0.67	0.34

Notes: Means and standard deviations for economic indicators over the years 2001 to 2007.

Table 4b: Descriptive Statistics

City	Primary industry proportion of GDP		Tertiary industry proportion of GDP		Annual utilized FDI/GDP		Income Ratio of Urban and Rural Dwellers		Inverse of Road Density		Public Green Space Per Capita (log)		Per Capita Electricity Consumption (log)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
East China														
Beijing	1.96	0.73	64.39	5.22	0.06	0.03	2.22	0.08	0.55	0.02	1.55	0.12	2.76	0.17
Tianjin	2.28	0.67	45.20	3.31	0.10	0.04	1.78	0.05	0.50	0.02	1.20	0.12	2.62	0.10
Shijiazhuang	1.26	0.18	54.00	4.10	0.11	0.06	2.41	0.18	0.46	0.01	1.36	0.06	2.61	0.08
Shenyang	2.18	0.44	51.17	2.33	0.08	0.02	2.06	0.05	0.47	0.02	1.58	0.09	2.62	0.12
Dalian	4.24	0.84	50.32	1.75	0.10	0.01	1.96	0.09	0.49	0.03	1.60	0.01	2.75	0.14
Jinan	3.60	1.48	52.16	5.15	0.03	0.01	2.91	0.10	0.47	0.02	1.29	0.12	2.65	0.09
Qingdao	2.29	0.86	45.07	3.20	0.08	0.02	2.24	0.11	0.49	0.02	1.57	0.09	2.72	0.15
Shanghai	0.99	0.34	50.44	1.48	0.06	0.01	2.24	0.06	0.55	0.03	1.21	0.18	2.80	0.15
Nanjing	2.28	0.94	48.65	2.25	0.06	0.02	2.27	0.23	0.50	0.03	2.00	0.25	2.68	0.09
Wuxi	1.35	0.61	43.31	1.54	0.08	0.02	1.93	0.14	0.48	0.02	1.70	0.13	2.72	0.11
Suzhou	1.95	1.07	37.03	2.36	0.15	0.07	1.91	0.11	0.52	0.03	1.42	0.14	2.69	0.17
Yangzhou	3.05	1.09	40.95	2.29	0.04	0.03	2.15	0.11	0.52	0.02	1.33	0.11	2.56	0.10
Hangzhou	3.31	1.00	48.01	2.57	0.03	0.01	2.24	0.04	0.53	0.04	1.41	0.08	2.77	0.10
Ningbo	2.43	0.46	45.37	2.61	0.07	0.01	2.25	0.03	0.52	0.04	1.30	0.14	2.66	0.17
Wenzhou	1.29	0.42	42.51	2.44	0.01	0.00	2.80	0.18	0.47	0.03	1.27	0.08	2.85	0.14
Shaoxing	3.61	1.56	47.90	2.54	0.04	0.02	2.20	0.08	0.55	0.04	1.51	0.18	2.49	0.18
Fuzhou	2.06	1.05	51.89	4.08	0.06	0.02	2.42	0.16	0.48	0.03	1.44	0.09	3.00	0.09
Xiamen	2.61	1.02	43.13	3.76	0.10	0.06	2.62	0.12	0.42	0.02	1.43	0.10	2.93	0.13
Guangzhou	2.44	0.66	56.60	4.04	0.06	0.02	2.51	0.10	0.50	0.01	2.21	0.11	2.95	0.10
Shenzhen	1.00	1.12	41.92	6.26	0.07	0.02	2.30	0.03	0.49	0.02	2.48	0.30	3.44	0.05

Zhuhai	2.99	1.07	42.01	2.67	0.12	0.05	2.91	0.13	0.37	0.03	1.67	0.08	2.93	0.08
Foshan	3.12	2.12	39.32	5.85	0.07	0.06	2.27	0.06	0.44	0.05	1.21	0.13	2.90	0.17
Dongguan	6.18	10.03	41.25	1.46	0.11	0.06	2.29	0.11	0.41	0.06	1.36	0.43	3.29	0.07
Haikou	6.23	2.95	64.94	4.58	0.12	0.06	2.61	0.11	0.32	0.06	1.35	0.11	2.29	0.09
Sanya	31.11	14.14	42.65	11.44	0.27	0.15	2.34	0.25	-0.14	0.21	1.41	0.20	2.43	0.19
Middle China														
Taiyuan	1.61	0.71	50.12	2.84	0.02	0.01	2.42	0.04	0.41	0.02	1.31	0.06	2.48	0.11
Changchun	2.54	0.75	43.90	2.56	0.05	0.02	2.76	0.27	0.45	0.05	1.32	0.07	2.56	0.05
Harbin	6.46	0.85	55.61	2.55	0.02	0.00	2.54	0.08	0.46	0.01	1.23	0.05	2.64	0.04
Heifei	1.23	0.52	45.38	4.91	0.05	0.02	3.07	0.13	0.47	0.03	1.47	0.08	2.73	0.14
Nanchang	1.56	1.01	44.60	2.22	0.05	0.02	2.63	0.08	0.45	0.05	1.29	0.15	2.52	0.19
Zhengzhou	2.01	1.87	60.50	6.93	0.02	0.01	2.20	0.08	0.45	0.03	1.26	0.21	2.83	0.06
Wuhan	5.09	2.51	49.49	2.53	0.05	0.02	2.50	0.12	0.51	0.04	1.00	0.19	2.60	0.19
Changsha	2.18	2.02	59.54	6.14	0.03	0.01	2.54	0.08	0.46	0.11	1.46	0.03	2.93	0.13
West China														
Chongqing	11.39	11.12	43.03	3.63	0.02	0.01	3.72	0.21	0.56	0.01	1.06	0.07	2.57	0.07
Chengdu	4.02	2.34	51.67	3.46	0.02	0.01	2.60	0.05	0.53	0.01	1.29	0.18	2.65	0.09
Guiyang	4.12	0.89	46.23	3.63	0.01	0.00	3.17	0.05	0.41	0.02	1.66	0.33	2.73	0.20
Kunming	2.37	0.50	49.15	4.25	0.00	0.00	3.05	0.07	0.48	0.02	1.38	0.06	2.70	0.12
Xi'an	3.51	0.59	50.42	3.16	0.03	0.01	2.78	0.07	0.42	0.02	1.04	0.13	2.53	0.08
Huhehaote	2.89	0.84	59.17	7.19	0.02	0.01	2.61	0.10	0.39	0.01	1.45	0.09	2.50	0.23

Notes: Means and standard deviations for economic indicators over the years 2001 to 2007.

Table 5: Correlation Matrix

	p	logs	n	h	logy	Urate	gdp1	gdp3	r	logg	loge	openness	iratio	celp
p	1.000													
logs	-0.393	1.000												
n	0.005	-0.251	1.000											
h	0.598	-0.361	0.051	1.000										
logy	-0.019	-0.126	-0.052	0.180	1.000									
Urate	0.451	-0.387	0.235	0.640	0.045	1.000								
gdp1	-0.329	0.367	-0.042	-0.206	0.196	-0.149	1.000							
gdp3	0.001	0.324	-0.259	0.168	-0.116	0.078	-0.122	1.000						
r	0.246	-0.235	0.023	0.240	-0.176	-0.040	-0.812	0.053	1.000					
logg	0.569	-0.237	-0.047	0.321	0.028	0.434	-0.151	-0.010	0.011	1.000				
loge	0.680	-0.525	0.072	0.460	0.143	0.234	-0.273	-0.222	0.207	0.498	1.000			
openness	0.115	-0.066	0.061	0.114	0.237	0.222	0.593	-0.277	-0.660	0.141	-0.008	1.000		
iratio	-0.321	0.311	-0.111	-0.182	-0.322	-0.245	0.125	0.009	-0.054	-0.184	-0.101	-0.384	1.000	
celp	0.679	-0.522	0.079	0.596	0.288	0.288	-0.125	-0.269	0.065	0.510	0.788	0.117	-0.120	1.000

Notes: Correlation is calculated based on the Mean value of each variable. *p*-interenet penetration rate; *n*-growth rate of population; *logs*-log of the propensity to accumulate physical capital; *h*-human capital index in 2000; *logy*-log of GDP per capita; *Urate*-urbanization rate; *gdp1/gdp3*-the proportion that primary/tertiary industry takes up in GDP; *r*-inverse of road density; *logg*-log of public green space per capita; *loge*-log of per capita electricity consumption; *openness*-actual utilized FDI over GDP; *iratio*-income ratio of urban and rural residents; *celp*-cellphone penetration rate.

Table 6: VIF value

Variables in Stage One	VIF	Tolerance
Log of Human Capital Index in 2000	1.45	0.689406
Internet Penetration Rate	1.31	0.765128
Log of the propensity to accumulate physical capital	1.16	0.859883
Growth rate of urban population	1.04	0.966011
Mean VIF	1.24	

Variables in Stage Two	VIF	Tolerance
Annual utilized FDI/GDP	2.74	0.365062
Log of Per Capita Electricity Consumption	2.55	0.392506
Cell phone Penetration Rate	2.36	0.423741
Primary Industry proportion of GDP	2.34	0.426949
Inverse of Road Surface Area Per Capita	1.95	0.513700
Log of GDP per capita	1.91	0.524579
Log of Public Green Space Per Capita	1.81	0.553209
Income ratio of urban to rural residents	1.33	0.754156
Tertiary Industry proportion of GDP	1.26	0.794420
Mean VIF	2.03	

Notes: Tolerance is the reciprocal of the VIF value.

Table 7: Internet Penetration and GDP per Capita

Dependent variable: Log of GDP per capita	Model 1	Model 2	Model 3	Model 4
Internet Penetration Rate	1.051***	1.138***	0.974***	1.115***
	(16.42)	*(19.47)*	*(14.63)*	*(17.87)*
Log of Capital formation/GDP	0.067***		0.118***	
	(2.40)		*(4.22)*	
Log of Human capital index	0.992***		(dropped)	
	(2.25)			
Growth of Urban population	-0.338**		-0.35**	
	(-2.05)		*(-2.23)*	
City dummies	No	No	Yes	Yes
Constant	2.533***	4.277***	4.419***	4.283***
	(3.17)	*(157.11)*	*(127.28)*	*(249.28)*
R2 (within)	0.6140	0.5783	0.6199	0.5783
F-test			15.12	14.98
Observations	273	273	273	273
Cities	39	39	39	39

Notes: First Stage of the Instrumental-Variable Model, estimation for 2001-2007. Sample of 39 main cities in China. Robust *t* statistics in parentheses. Significance at * 10%, **5%, ***1%.

Table 8: GDP per capita and Urban Population Proportion

Dependent variable: Urban Population Proportion	Model 1	Model 2	Model 3	Model
Predicted Log of GDP per capita	0.219***	0.132**	0.248***	0.292***
	(4.93)	*(2.45)*	*(5.79)*	*(8.18)*
Log of Capital formation/GDP	0.019			
	(0.88)			
Log of Human capital index	(dropped)			
Growth of Urban population	-0.059***			
	(-5.72)			
Primary Industry proportion of GDP		-0.673**	-0.934***	
		(-2.35)	*(-3.26)*	
Tertiary Industry proportion of GDP		0.019	0.679	
		(0.25)	*(0.85)*	
Annual utilized FDI/GDP		0.219	0.157	
		(1.27)	*(0.91)*	
Income ratio of urban to rural residents		0.041	0.061*	
		(1.33)	*(1.95)*	
Cell phone Penetration Rate		0. 024***		
		(2.97)		
Inverse of Road Surface Area Per Capita		-0.309		
		*(-2.16)***		
Log of Public Green Space Per Capita		-0.009		
		(-0.26)		
Log of Per Capita Electricity Consumption for Residential Use		0.152***		
		(3.20)		
City dummies	Yes	Yes	Yes	Yes
Constant	-0.464**	-0.645***	-0.772***	-0.817***
	(-2.16)	*(-2.88)*	*(-3.94)*	*(-5.00)*
R2 (within)	0.3215	0.3928	0.3102	0.2231
F-test	38.79	70.18	69.06	
Observations	273	273	273	273
Cities	39	39	39	39

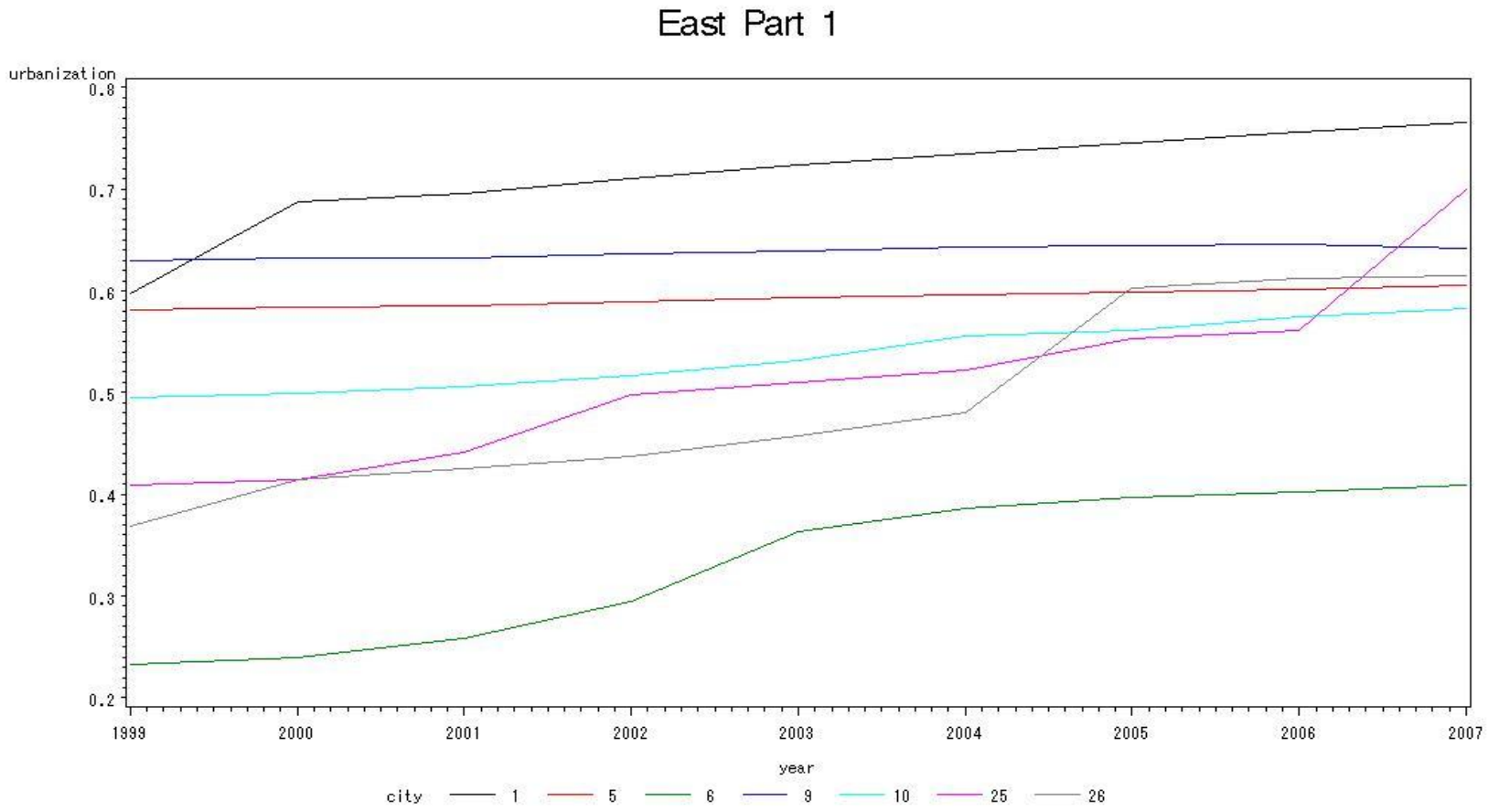
Notes: Second Stage of the Instrumental-Variable Model, estimation for 2001-2007. Sample of 39 main cities in China. Standard errors in brackets. Robust *t* statistics in parentheses. Significance at * 10%, **5%, ***1%.

Table 9: Test on other explanatory variables

Dependent variable: Log of Capital formation/GDP	**Model**
Primary Industry proportion of GDP	-2.591*** *(-2.68)*
Tertiary Industry proportion of GDP	-0.577** *(-1.95)*
Annual utilized FDI/GDP	1.470*** *(2.57)*
Income ratio of urban to rural residents	0.267*** *(2.90)*
Cell phone Penetration Rate	-0.044 *(-1.51)*
Inverse of Road Surface Area Per Capita	0.619** *(2.04)*
Log of Public Green Space Per Capita	0.189* *(1.58)*
Log of Per Capita Electricity Consumption for Residential Use	0.734*** *(4.97)*
City dummies	Yes
Constant	-3.731*** *(-8.49)*
R2 (within)	0.3432
F-test	
Observations	273
Cities	39

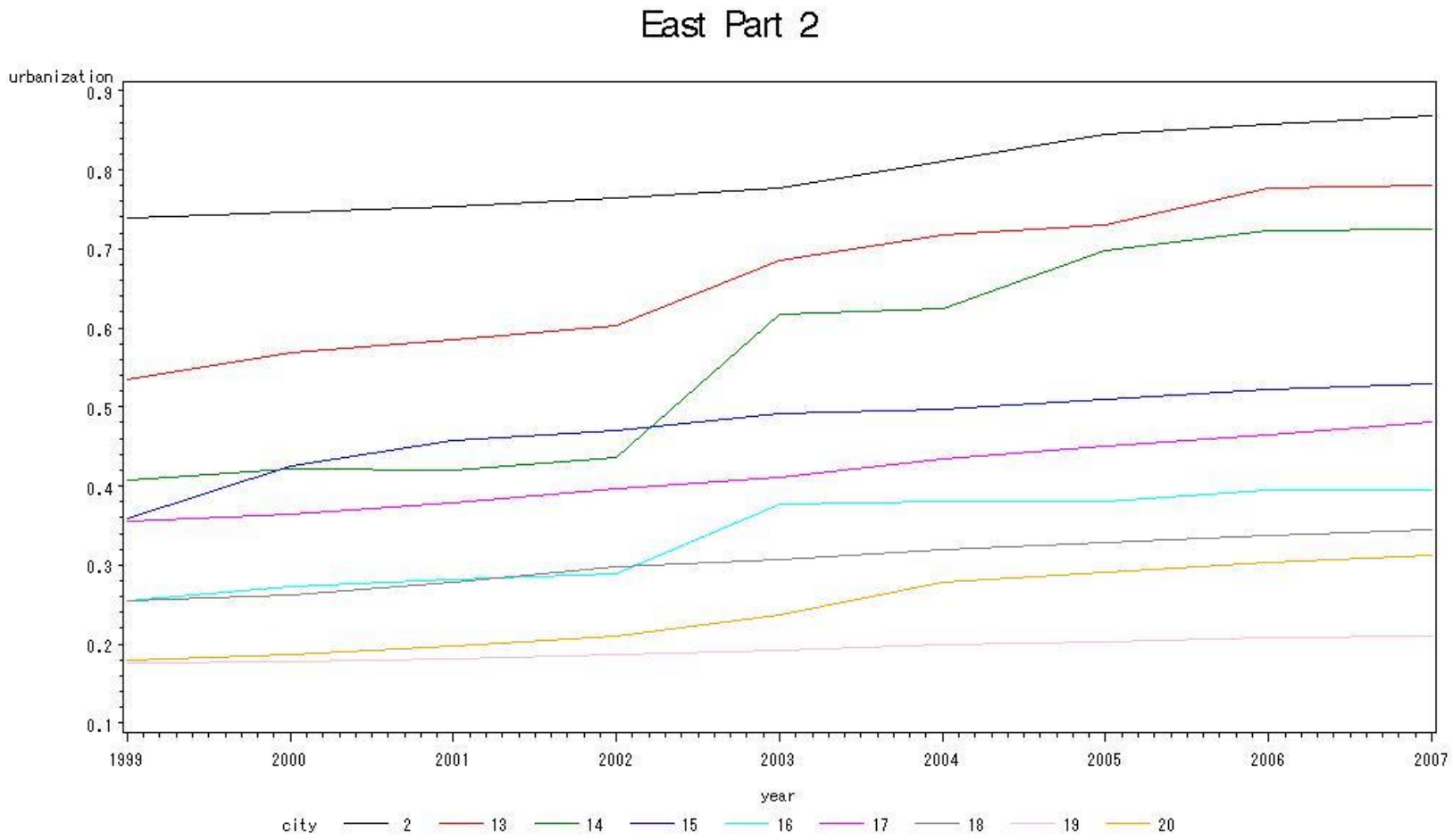
Notes: Test on the relationship between Capital Formation/GDP and other factors that impact urbanization, estimation for 2001-2007. Sample of 39 main cities in China. Standard errors in brackets. Robust t statistics in parentheses. Significance at * 10%, **5%, ***1%.

Figure 1a: Urbanization Rate (1999-2007) East China 1



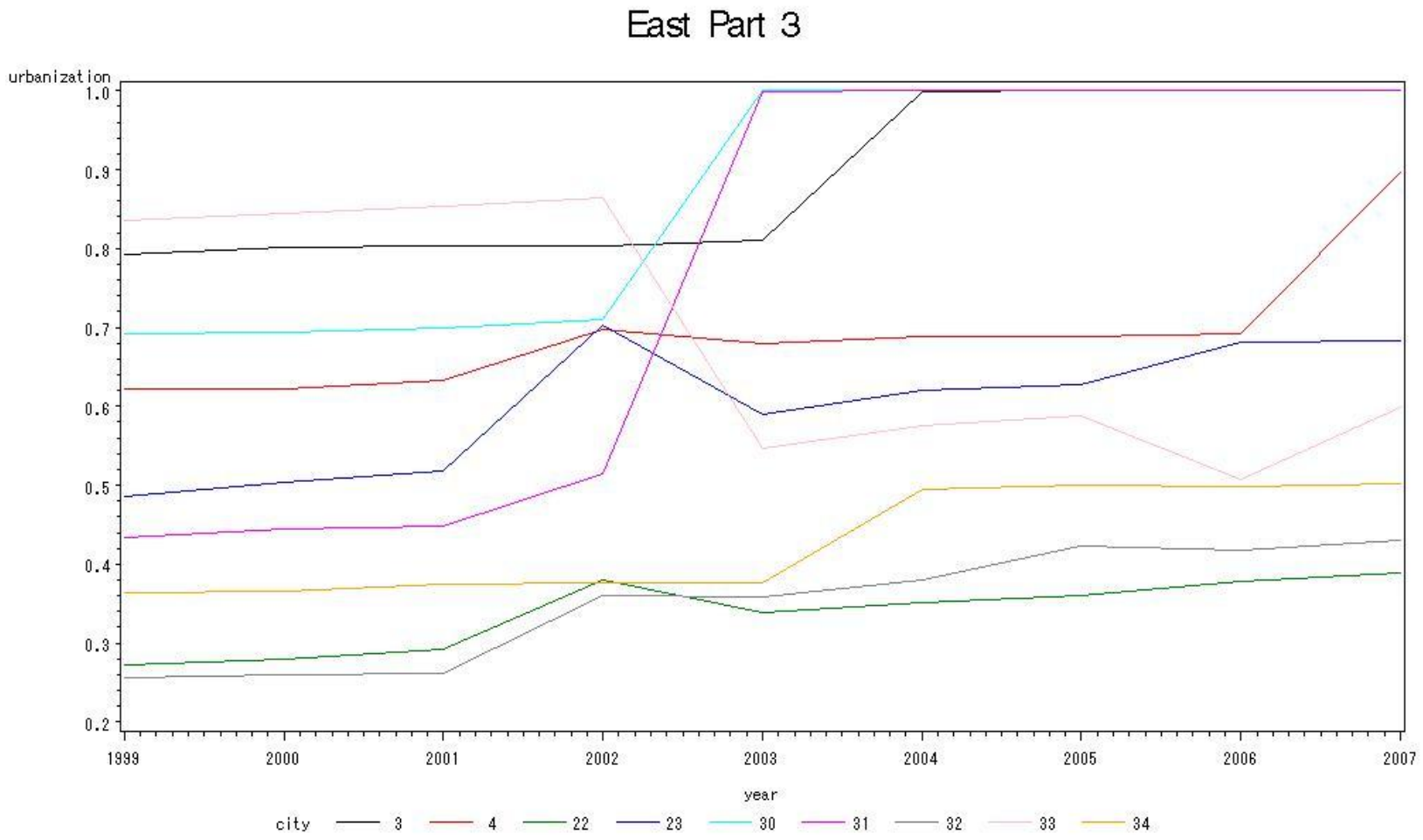
Note: City 1 – Beijing, City 5 – Tianjin, City 6 – Shijiazhuang, City 9 – Shenyang, City 10 – Dalian, City 25 – Jinan, City 26 – Qingdao.

Figure 1b: Urbanization Rate (1999-2007) East China 2



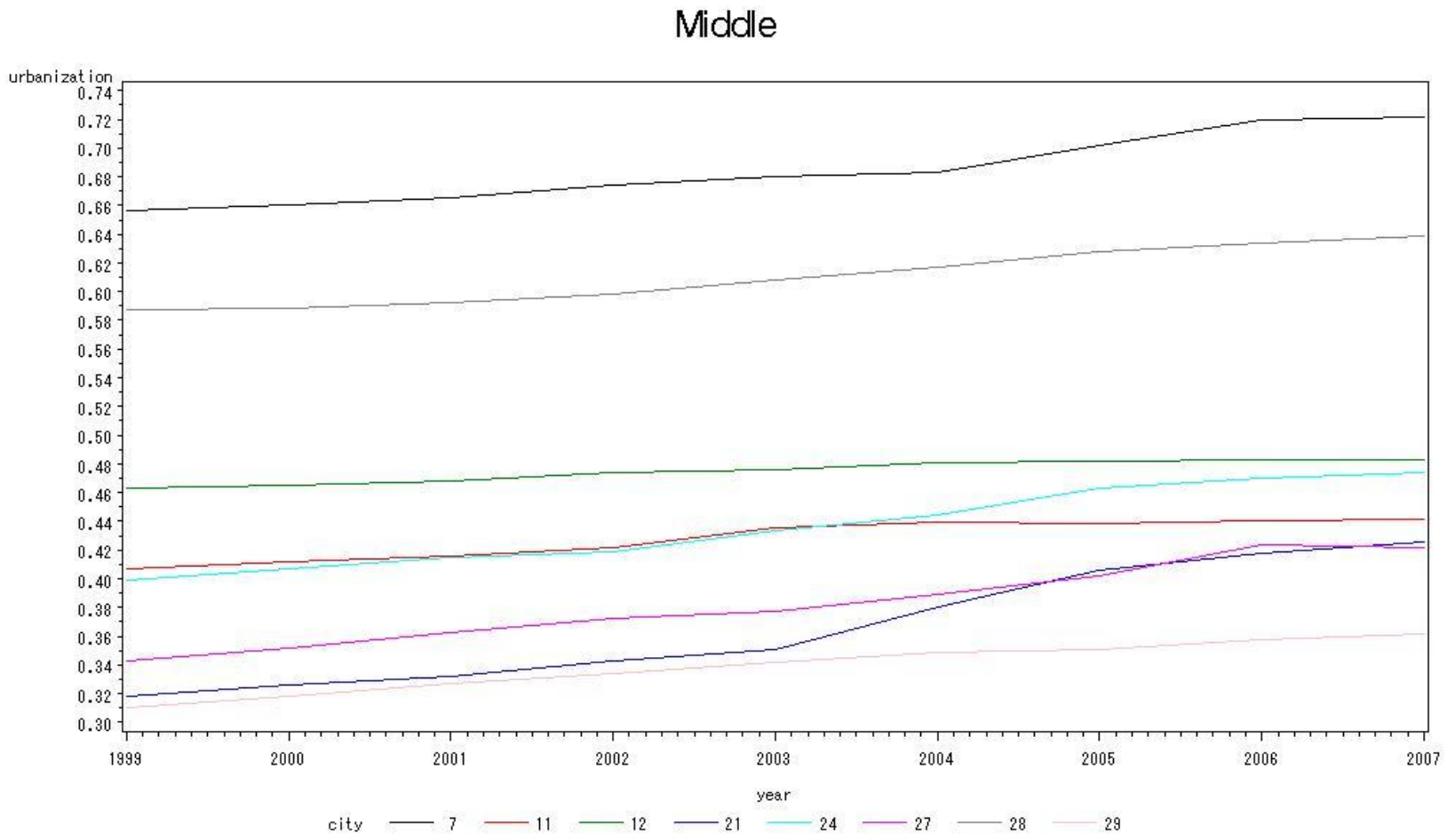
Note: City 2 – Shanghai, City 13 – Nanjing, City 14 – Wuxi, City 15 – Suzhou, City 16 – Yangzhou, City 17 – Hangzhou, City 18 – Ningbo, City 19 – Wenzhou, City 20 – Shaoxing.

Figure 1c: Urbanization Rate (1999-2007) East China 3



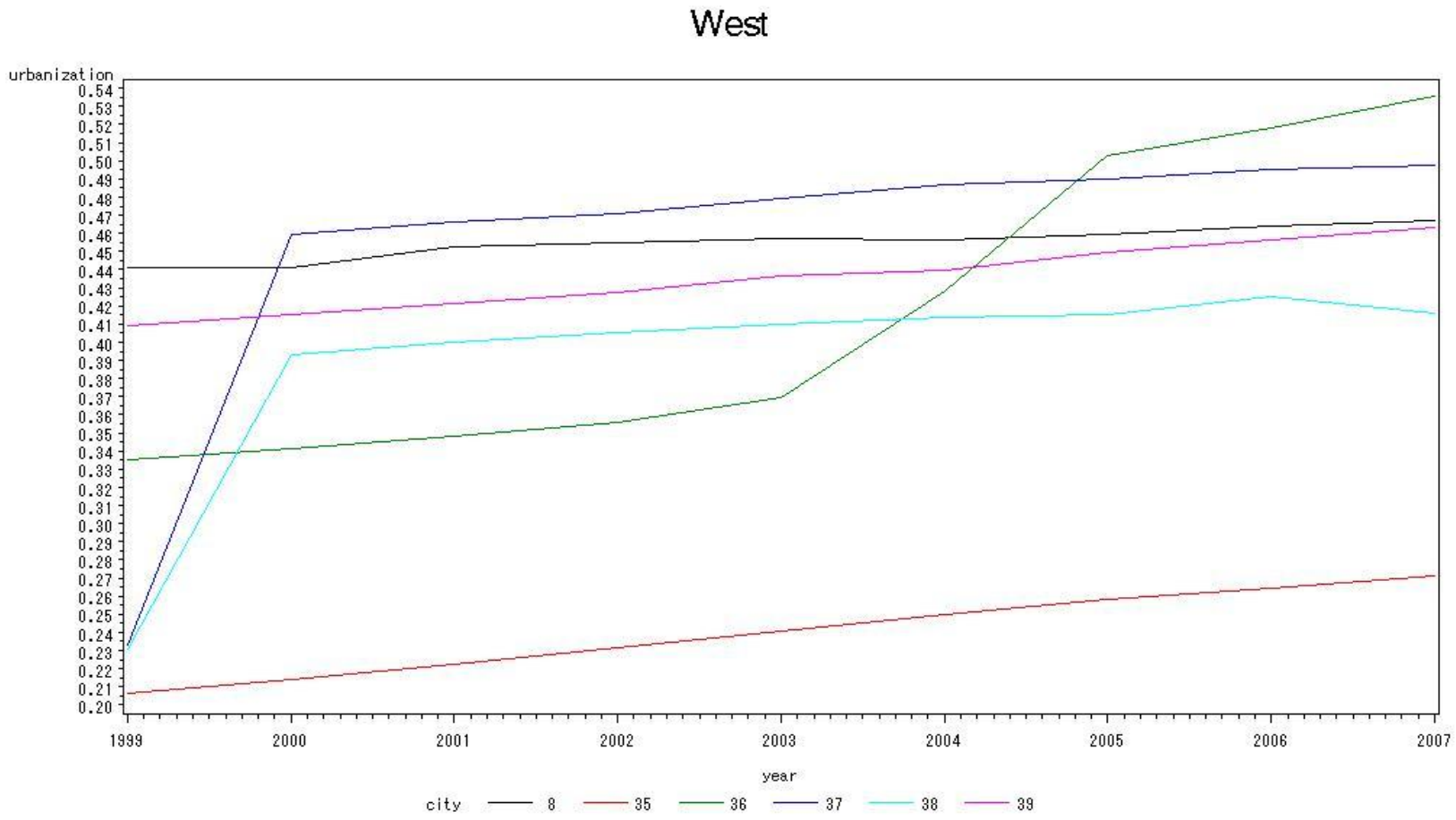
Note: City 3 – Shenzhen, City 4 – Guangzhou, City 22 – Fuzhou, City 23 – Xiamen, City 30 – Zhuhai, City 31 – Foshan, City 32 – Dongguan, City 33 – Haikou, City 34 – Sanya.

Figure 1d: Urbanization Rate (1999-2007) Middle China



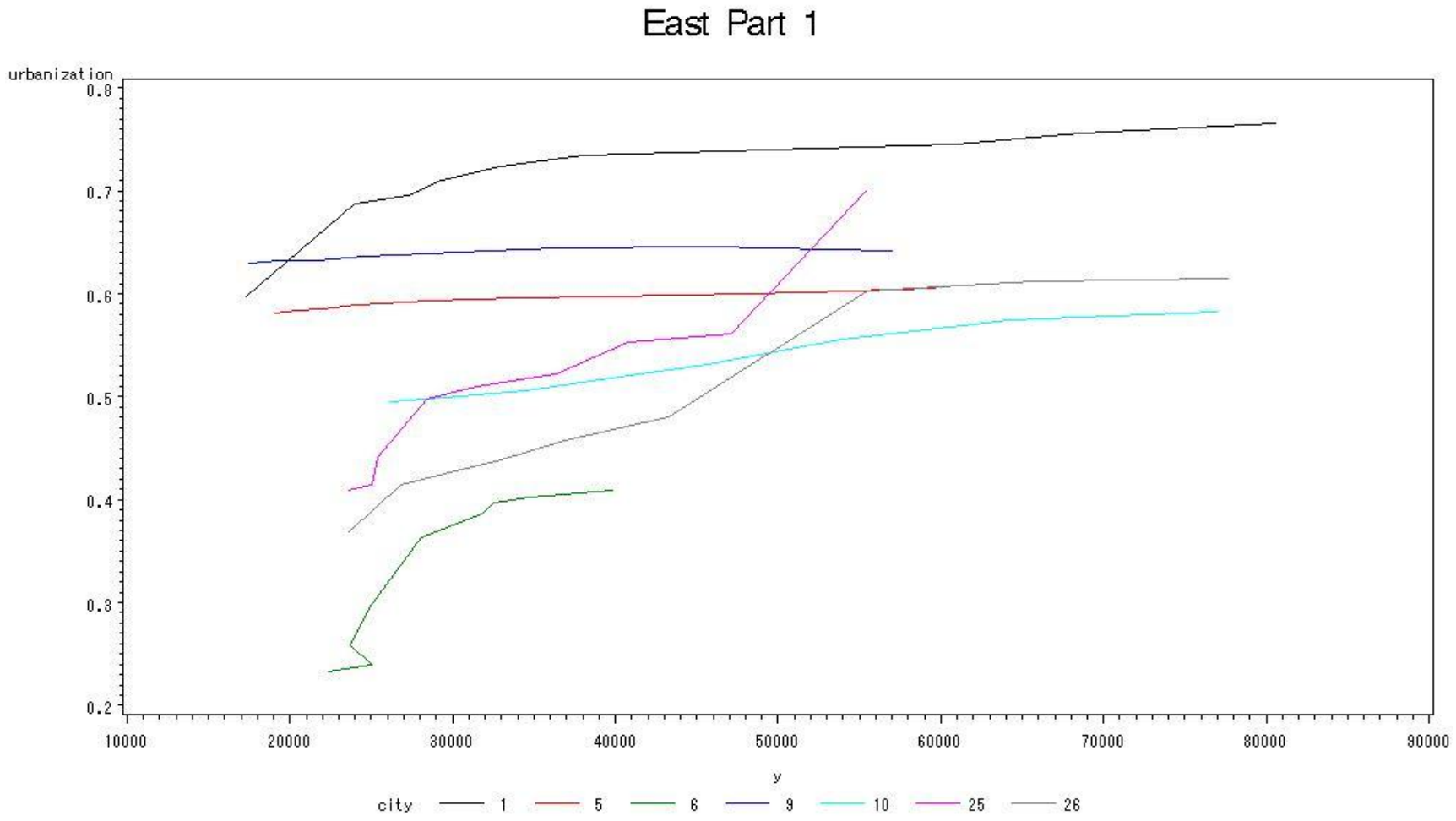
Note: City 7 – Taiyuan, City 11 – Changchun, City 12 – Harbin, City 21– Hefei, City 24 – Nanchang, City 27 – Zhengzhou, City 28 – Wuhan, City 29 – Changsha.

Figure 1e: Urbanization Rate (1999-2007) West China



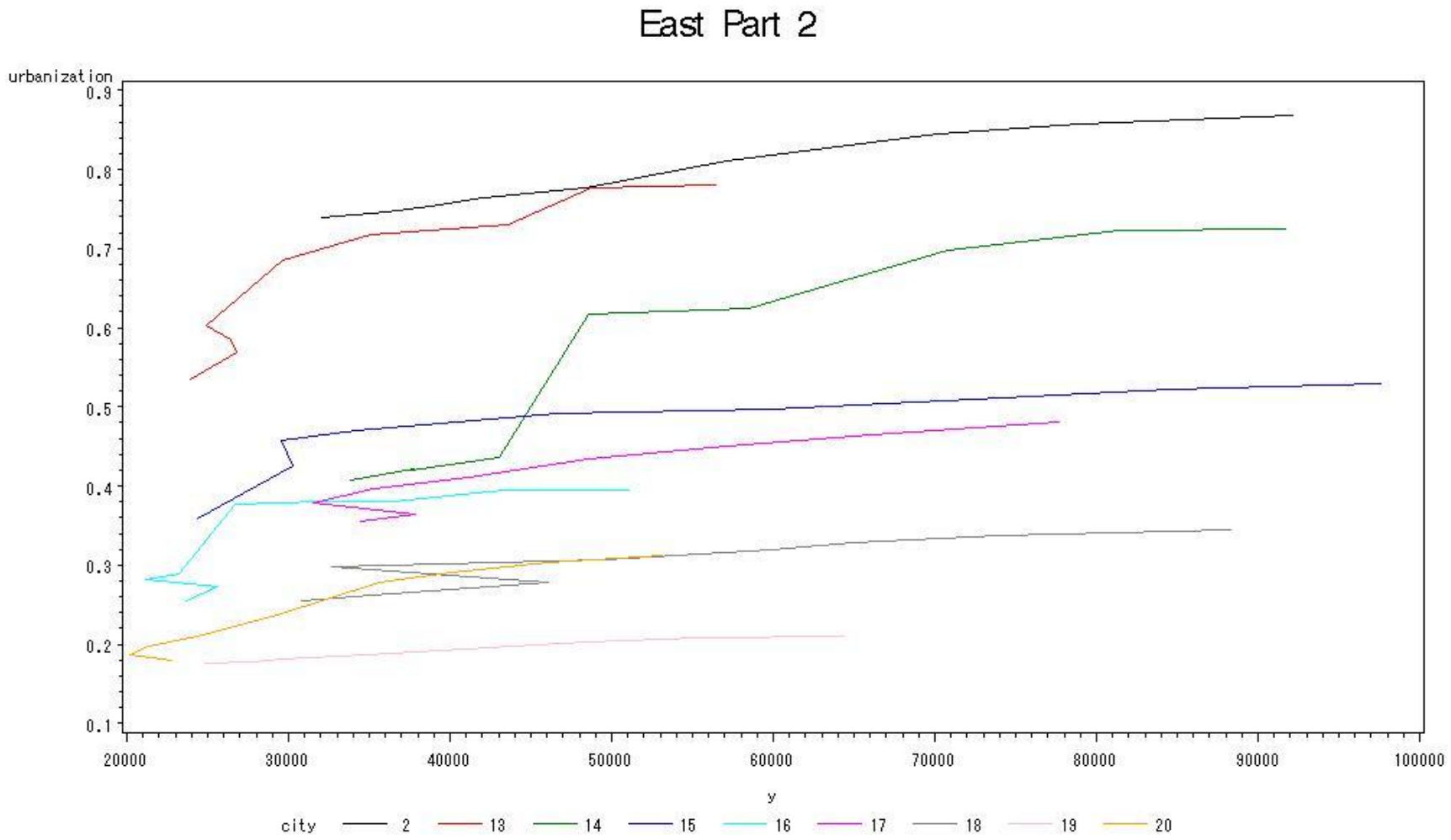
Note: City 8 – Huhehaote, City 35 – Chongqing, City 36 – Chengdu, City 37 – Guiyang, City 38 – Kunming, City 39 – Xi'an.

Figure 2a: Urbanization Rate and GDP per capita (1999-2007) East China 1



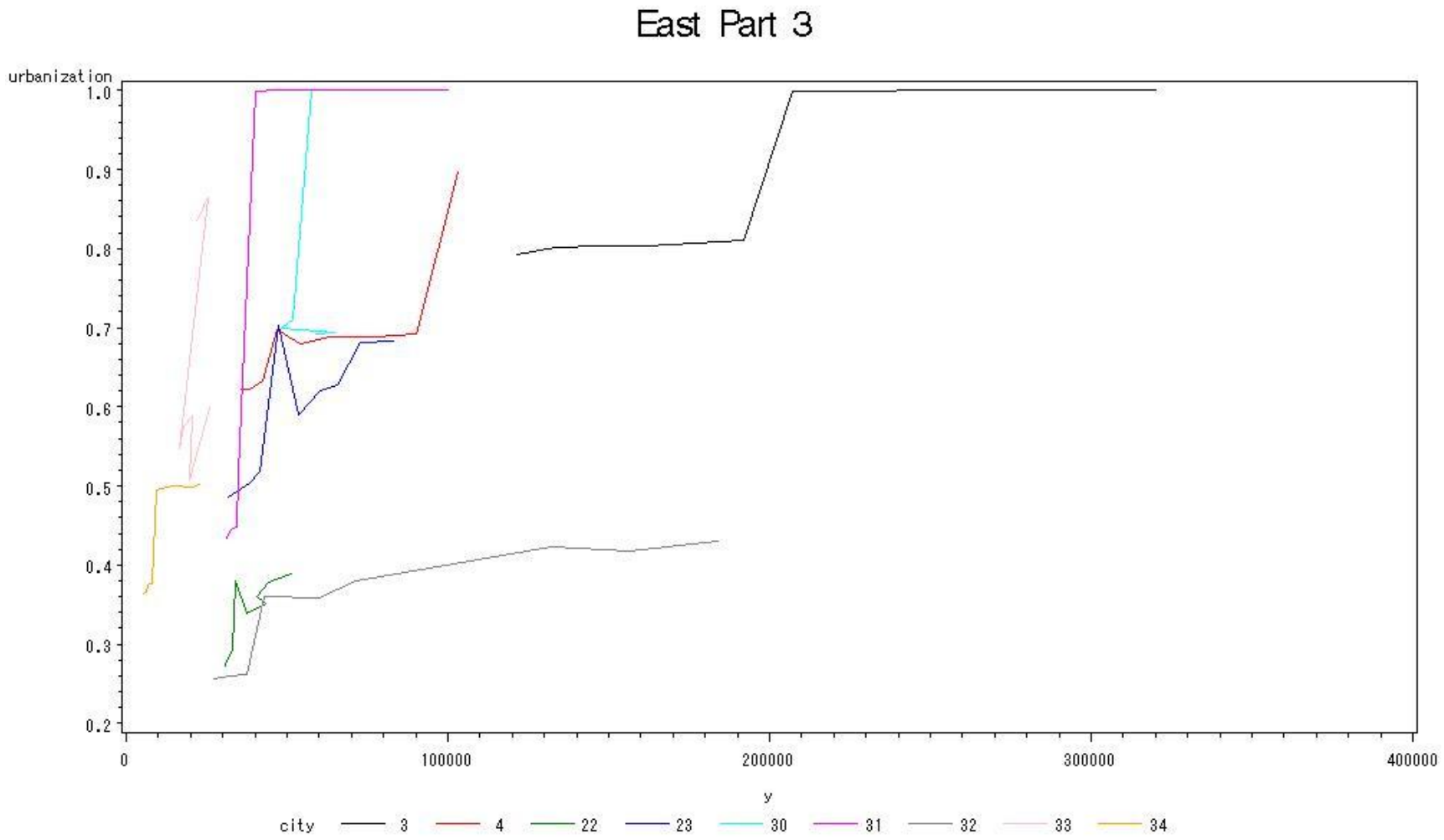
Note: City 1 – Beijing, City 5 – Tianjin, City 6 – Shijiazhuang, City 9 – Shenyang, City 10 – Dalian, City 25 – Jinan, City 26 – Qingdao.

Figure 2b: Urbanization Rate and GDP per capita (1999-2007) East China 2



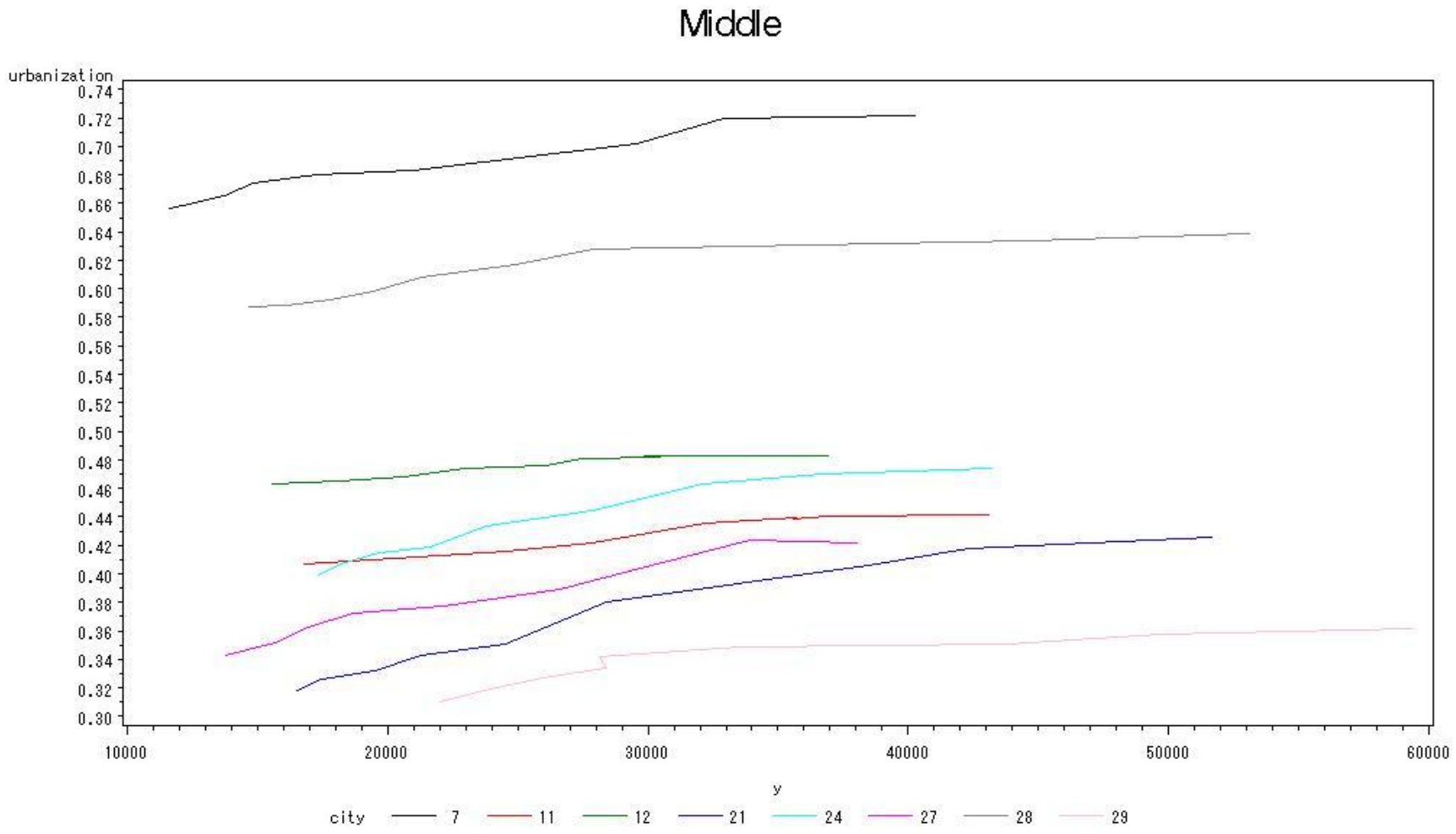
Note: City 2 – Shanghai, City 13 – Nanjing, City 14 – Wuxi, City 15 – Suzhou, City 16 – Yangzhou, City 17 – Hangzhou, City 18 – Ningbo, City 19 – Wenzhou, City 20 – Shaoxing.

Figure 2c: Urbanization Rate and GDP per capita (1999-2007) East China 3



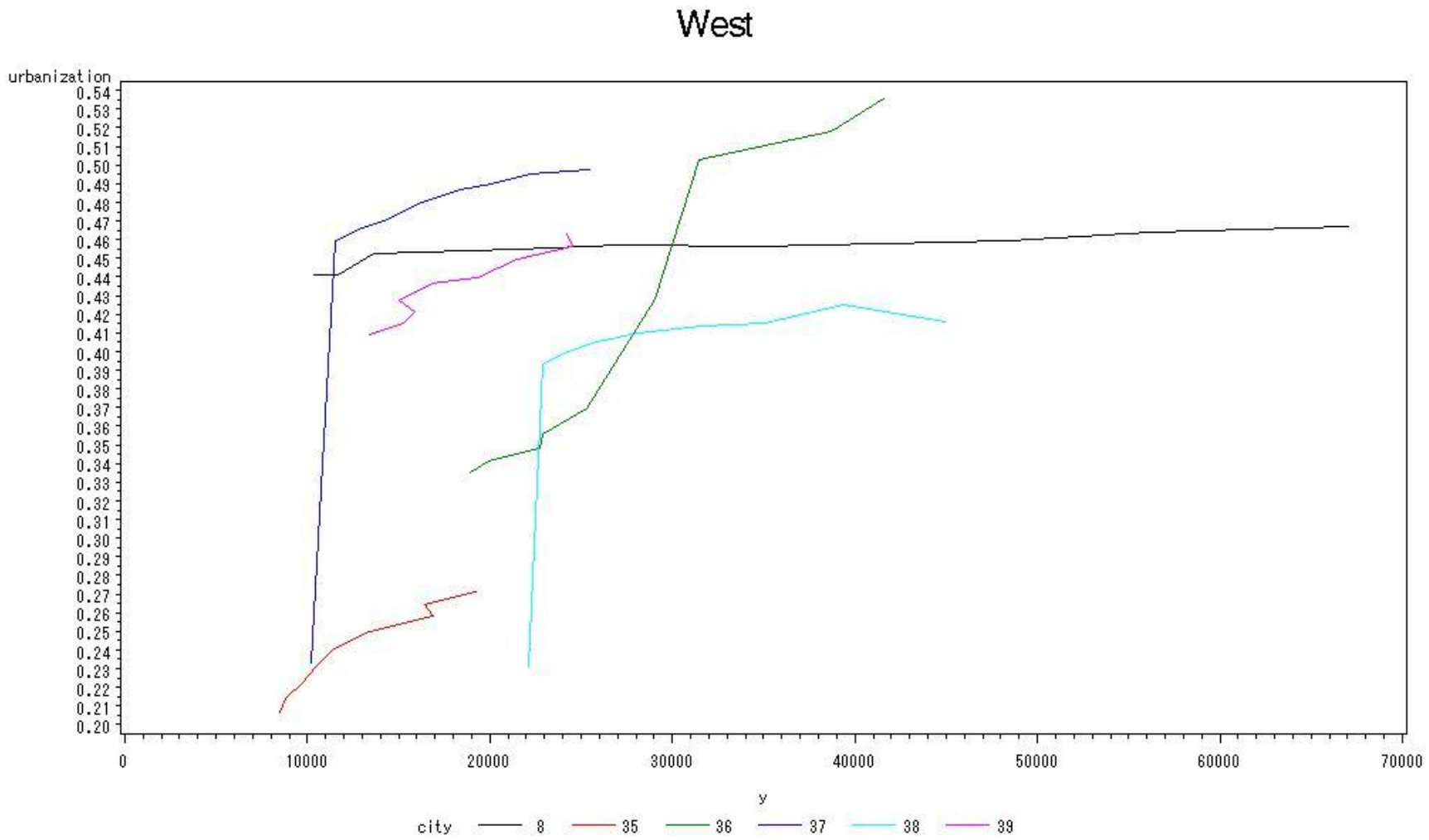
Note: City 3 – Shenzhen, City 4 – Guangzhou, City 22 – Fuzhou, City 23 – Xiamen, City 30 – Zhuhai, City 31 – Foshan, City 32 – Dongguan, City 33 – Haikou, City 34 – Sanya.

Figure 2d: Urbanization Rate and GDP per capita (1999-2007) Middle China



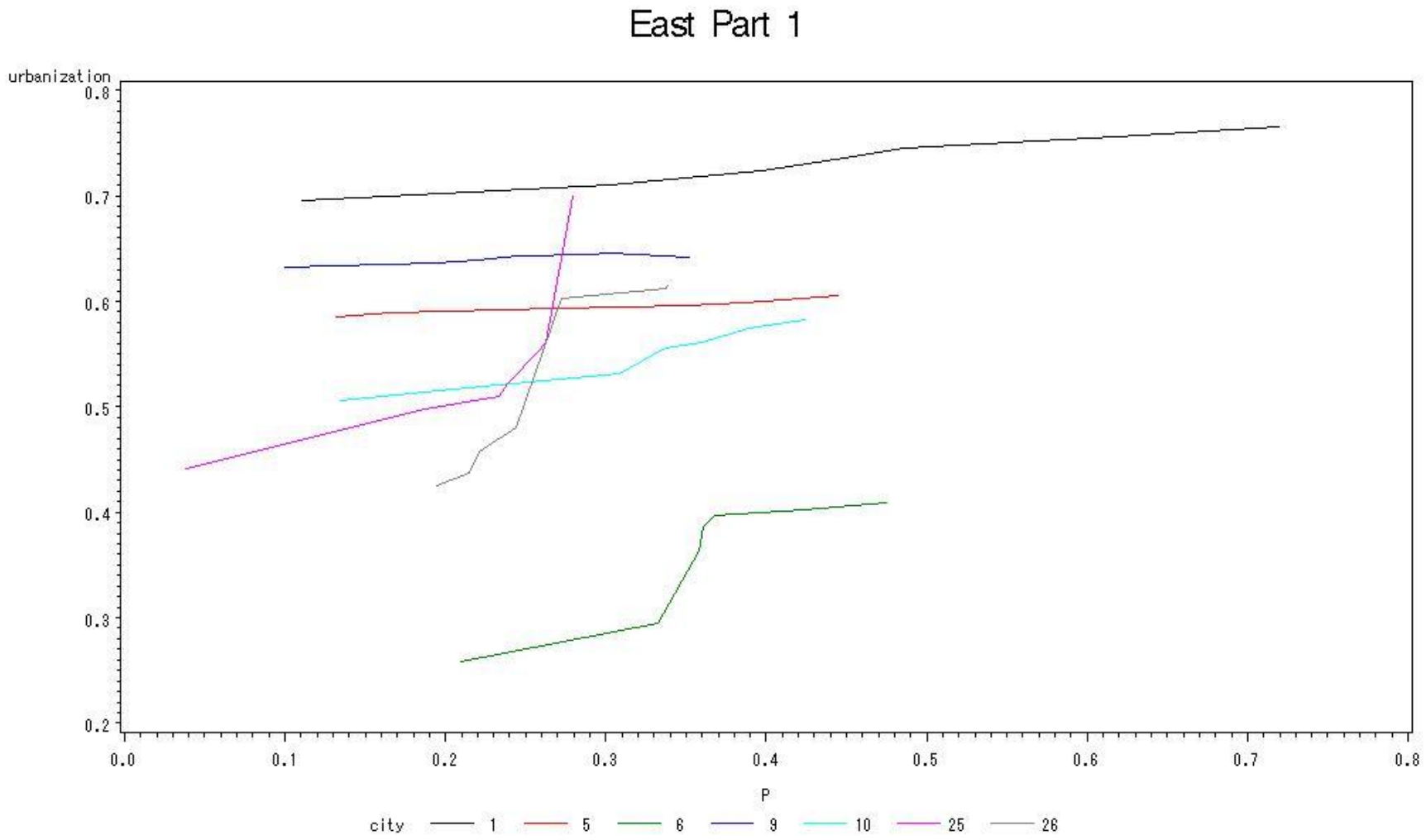
Note: City 7 – Taiyuan, City 11 – Changchun, City 12 – Harbin, City 21– Hefei, City 24 – Nanchang, City 27 – Zhengzhou, City 28 – Wuhan, City 29 – Changsha.

Figure 2e: Urbanization Rate and GDP per capita (1999-2007) West China



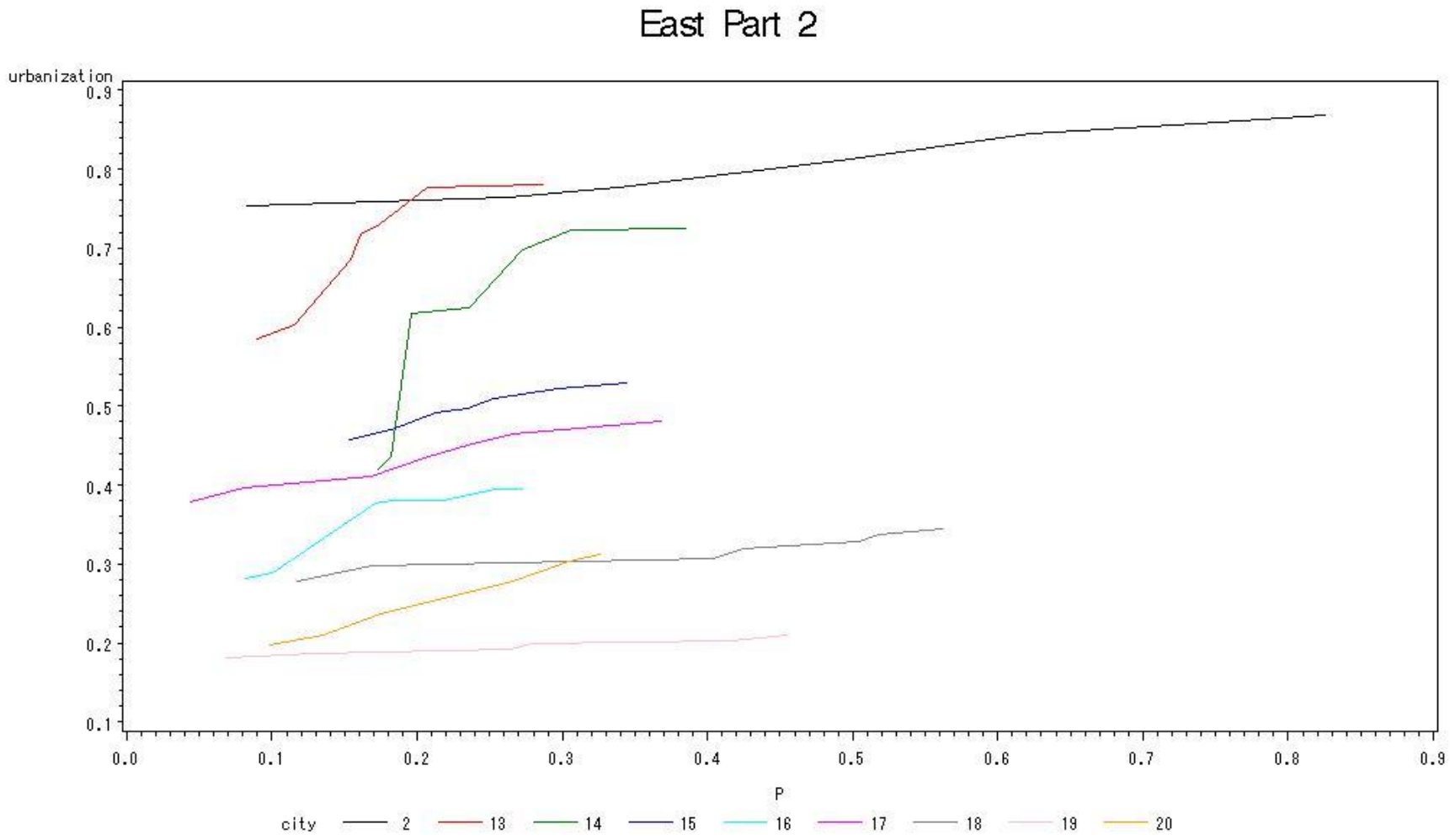
Note: City 8 – Huhehaote, City 35 – Chongqing, City 36 – Chengdu, City 37 – Guiyang, City 38 – Kunming, City 39 – Xi'an.

Figure 3a: Urbanization Rate and Internet Penetration rate (2001-2007) East China 1



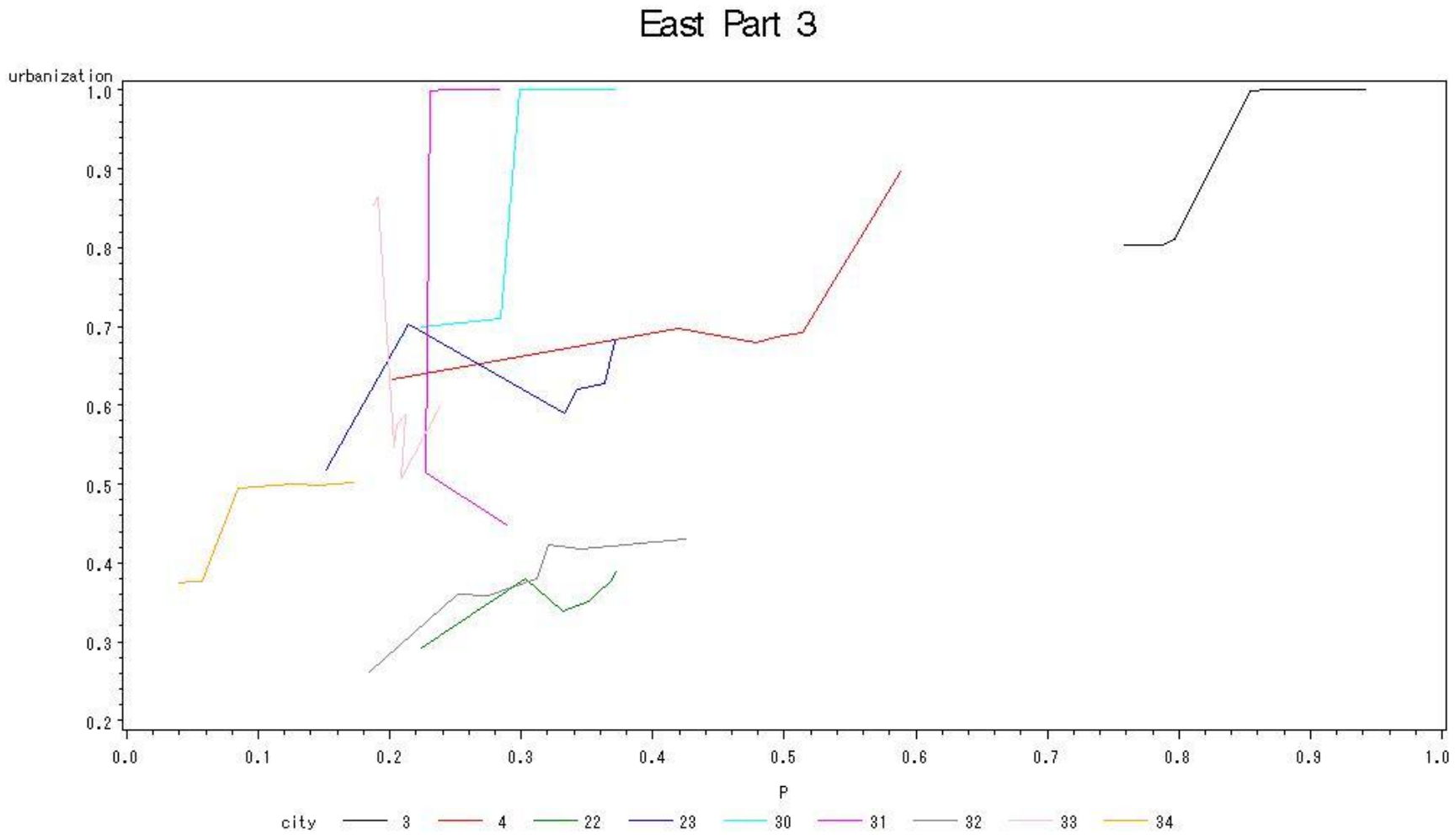
Note: City 1 – Beijing, City 5 – Tianjin, City 6 – Shijiazhuang, City 9 – Shenyang, City 10 – Dalian, City 25 – Jinan, City 26 – Qingdao.

Figure 3b: Urbanization Rate and Internet Penetration rate (2001-2007) East China 2



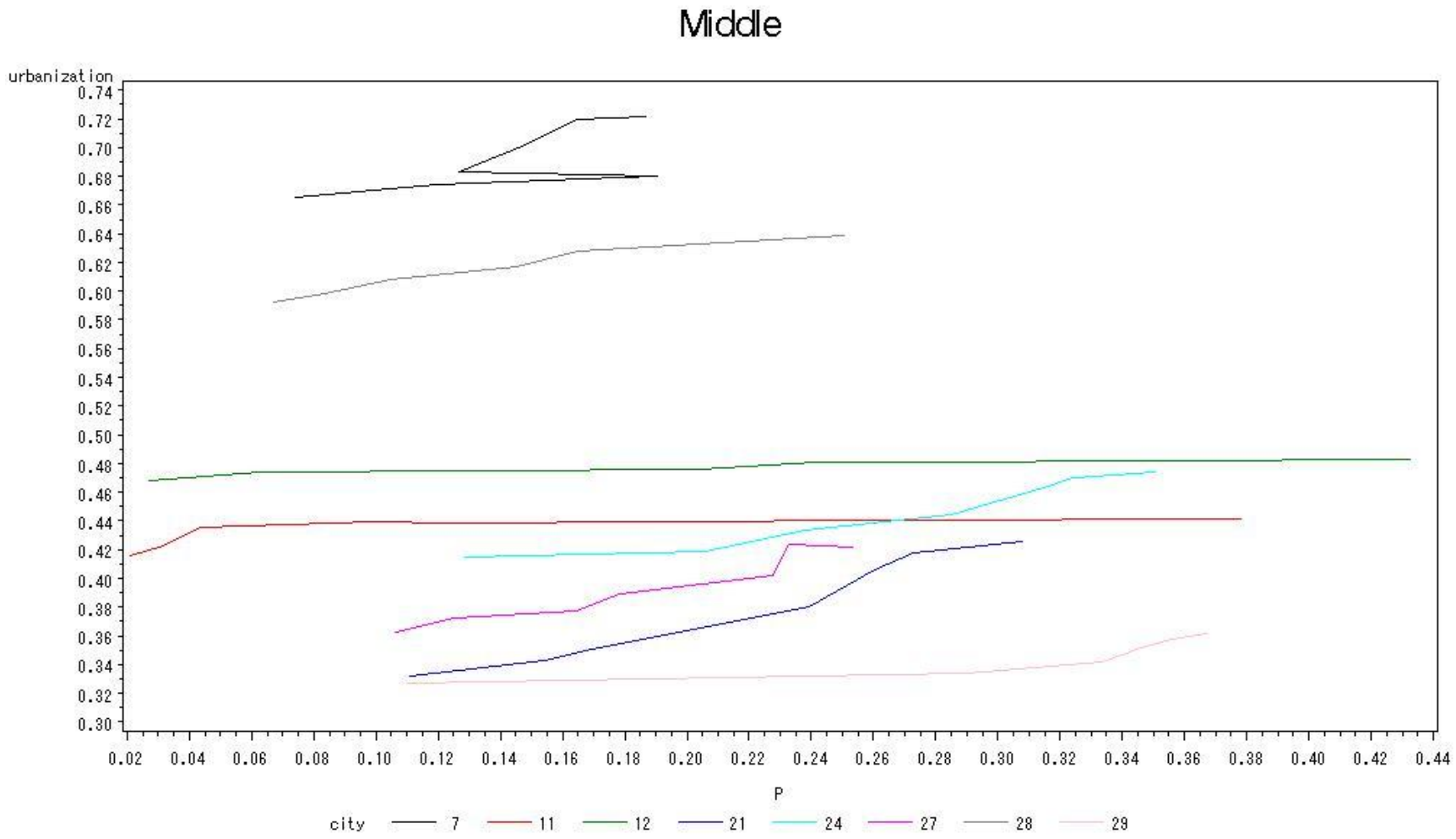
Note: City 2 – Shanghai, City 13 – Nanjing, City 14 – Wuxi, City 15 – Suzhou, City 16 – Yangzhou, City 17 – Hangzhou, City 18 – Ningbo, City 19 – Wenzhou, City 20 – Shaoxing.

Figure 3c: Urbanization Rate and Internet Penetration (2001-2007) East China 3



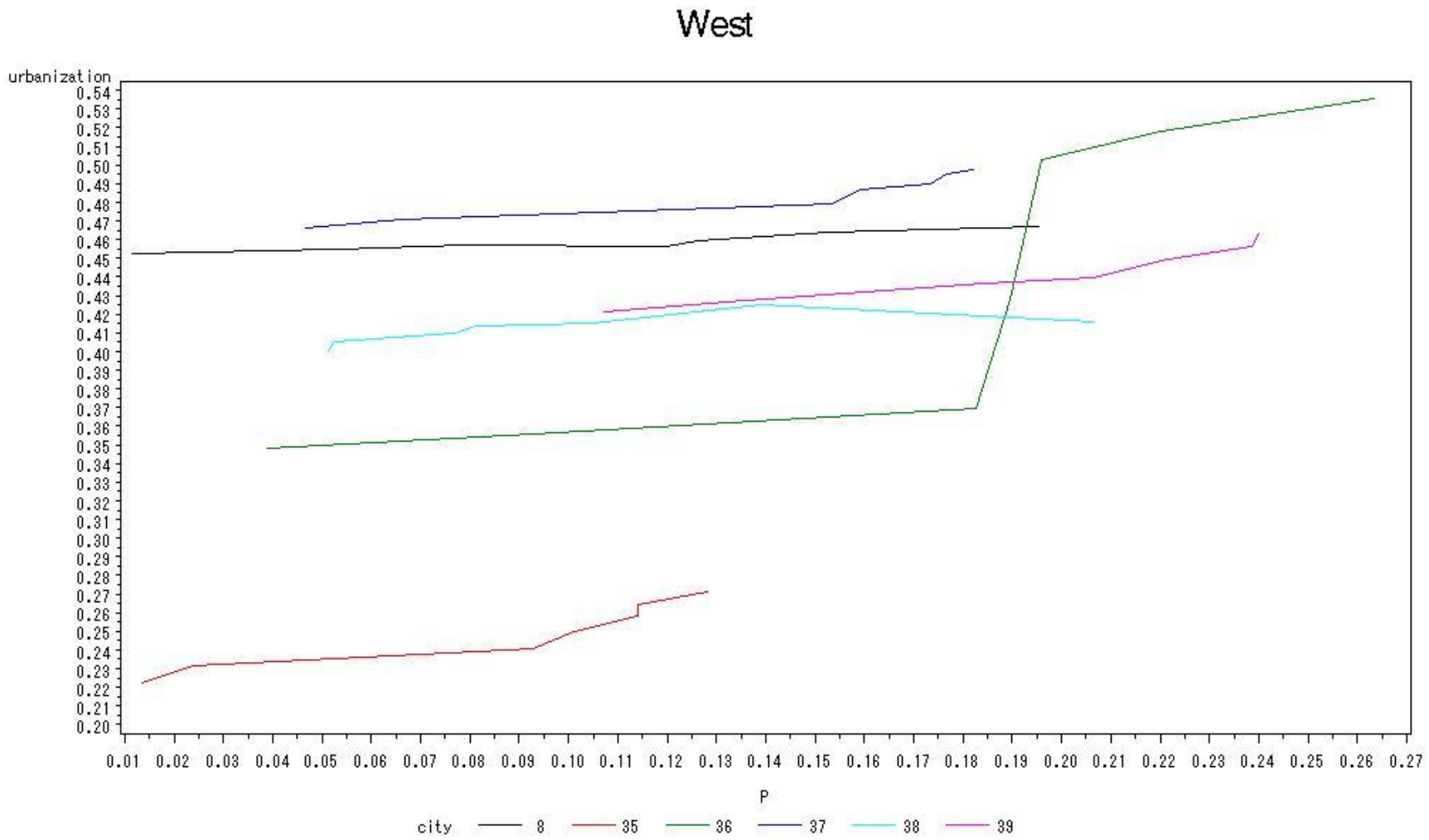
Note: City 3 – Shenzhen, City 4 – Guangzhou, City 22 – Fuzhou, City 23 – Xiamen, City 30 – Zhuhai, City 31 – Foshan, City 32 – Dongguan, City 33 – Haikou, City 34 – Sanya.

Figure 3d: Urbanization Rate and Internet Penetration (2001-2007) Middle China



Note: City 7 – Taiyuan, City 11 – Changchun, City 12 – Harbin, City 21– Hefei, City 24 – Nanchang, City 27 – Zhengzhou, City 28 – Wuhan, City 29 – Changsha.

Figure 3e: Urbanization Rate and Internet Penetration (2001-2007) West China



Note: City 8 – Huhehaote, City 35 – Chongqing, City 36 – Chengdu, City 37 – Guiyang, City 38 – Kunming, City 39 – Xi'an.